Diversity in Engineering Technology: Competitions

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Abstract:
The United States will face a serious shortage of scientists, engineers, technologists, and mathematicians because high school students are losing interest in science and math, especially those students from underrepresented groups. The Diversity in Engineering Technology project is doing something about this problem. We encourage women, minorities, and persons with disabilities to stay in math and science courses through participation in newly established engineering clubs at the high schools. Our goal is to increase the students' interest in engineering by demonstrating how the math and science concepts they are learning in class are applied in real life to engineering problems.

The Junior Engineering Technical Society and UNC Charlotte have joined forces to encourage more women and minorities to become interested in engineering and engineering technology by establishing engineering clubs and engaging these students in competitions. The Junior Engineering Technical Society (JETS) is a national non-profit education organization that has served the pre-college engineering community for over 50 years.

The engineering clubs will participate in the Tests of Engineering Aptitude, Mathematics and Science (TEAM+S) competition developed by JETS. The TEAM+S competition is an academically challenging, open-book, open-discussion exam taken by teams of four-to-eight high school students. TEAM+S presents the multidisciplinary aspect of engineering work by illustrating how math and science concepts work together and are applied to solve real-world problems.

JETS and the Diversity in Engineering Technology project promote interest in engineering and engineering technology and are dedicated to providing real world engineering and problem-solving experiences to high school students. Through the engineering clubs, students will discover engineering while in high school, find out what engineers do, and learn how math and science is applied to real life engineering problems.

This paper will focus on the JETS' TEAM+S competitions. We will describe how to host a competition, how to recruit participants in your region, provide examples of the problems

students will solve during the competition, and share the results of the first JETS competition hosted by UNC Charlotte.

Rationale for the Project:

In the near future, the United States will face a serious shortage of scientists, engineers, technologists, and mathematicians because high school students from underrepresented groups are losing interest in these subjects[1]. These students are depriving themselves of many technical and scientific career choices, as well as access to high salaried occupations[2]. In 1995, women constituted about 46 percent of the U.S. labor force but only about 22 percent of the scientific and engineering labor force[3].

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 decreasing[4]. 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 disabilities[5].

The Engineering Technology Department at UNC Charlotte has been funded by the National Science Foundation to implement a project that encourages students typically underrepresented in science, technology, engineering, and math (STEM) careers to become interested in engineering and engineering technology to address the problem. The focus of the project is to establish engineering and engineering technology clubs at public high schools in the Charlotte, North Carolina region and then to support the clubs through engaging, hands-on activities. Competitions are one of the activities used to encourage and challenge young people from our region to participate in the clubs.

JETS Competitions:

The Tests of Engineering Aptitude Mathematics and Science (TEAM+S) challenges high school students in ways that no other program does. **TEAM+S** is a rigorous competition in which a group of four to eight high school students learn team development and problem-solving skills, and then participate in an open-book, open-discussion, engineering problem competition. From this one test, teams receive local, state and national recognition.

Figure 1: Students taking the TEAM+S Test at UNC Charlotte

TEAM+S is split into two sections. The first section involves ten problem statements with background information: i.e.; formulas, assumptions, etc. For each of the problem statements there are ten multiple-choice questions. Students must work as a team; cooperatively and organized to be able to finish in good standing. The students are given 90 minutes to complete the first section.

The test booklets explain to students that even very good teams will only complete 50 to 60% of the test. Why is the test so long and rigorous (90 minutes to complete 100 demanding and difficult questions)? The test is difficult so that the students are challenged and so that a "clear" national winner advances from the competitions.

TEAM+S competitions are held between the second week in February and the third week in March at over 90 colleges and universities and reaches 1,600 high schools and 13,000 high school students across the country.

This is the first year that UNC Charlotte will host a TEAM+S Competition. We are expecting 18 schools to participate with at least one team from each school. This year, UNC Charlotte will host 100 high school students (potential UNC Charlotte engineering or engineering technology students) to compete in the TEAM+S Test. Immediately after the TEAM+S Test the students will participate in a robotic competition (see below: Other Competitions).

The benefits of hosting a TEAM+S competition include: the opportunity to talk with some of the area's best and brightest students about engineering, and your department's programs, serving as a resource to high school students, many of whom are making college and career choices, and placing your organization alongside other engineering organizations working together for the good of the community,

TEAM+S is now in its 25th year and is JETS most successful engineering program. Each year, 90 locations (mostly colleges & universities) host over 1,600 teams and 13,000 students across the country. Thirty-five percent of the students participating in TEAM+S Test nationwide are female. In fact, the high schools participating in the TEAM+S Competitions have been very successful in recruiting a diverse group of students to participate.

Table 1:
Demographic Data at UNC Charlotte, the U.S., and in the Region

	White	African-American	Hispanic[3]	Asian	Male	Female
UNC Charlotte	76.7%	13.6%	1.3%	4.6%	90.7%	9.3%
National Stats in Eng./Tech[1]	69.3%	7.6%	5.7%	6.5	89.3%	10.7%
Regional Population [2]	74.7%	19.4%	5.0%	2.1%	48.3%	51.7%
National Participation in TEAM+S[4]	74.7%	2.3%	4.6%	12.5%	65%	35%

[1] from ASEE [2] 2000 US Census Bureau [3] Hispanic – any race [4] National Statistics from JETS

The table above shows that we need to provide more encouragement to women, African-Americans, and Latinos in this region to consider STEM careers. The demographic data for those who participated in the TEAM+S Competition at UNC Charlotte this year is shown below.

Table 2: Demographic Data of Participants in the TEAM+S Competition at Charlotte this year[1]										
Male					Female					
African-American	Asian	Hispanic	White	Other	African-American	Asian	Hispanic	White	Other	Total
5	5	4	37	12	1	2	3	18	3	90
5.6%	5.6%	4.4%	41.1%	13.3%	1.1%	2.2%	3.3%	20%	3.3%	
			Total	63					Total	27
			Percentage	70%					Percentage	30%

[1] Approximately 150 students were present, 97 participated in TEAM+S, 90 participated in the survey

Tables 3 and 4 show the demographic data for the clubs established through this project. Although the number of African American students participating in the competition this year is lower than the number of African American students involved in the clubs, we are sure that this will improve next year. We were informed two days before the competition that two of the schools (with a high African American population) were unable to secure transportation to the competition this year.

Table 3: Demographic Data of the High School Clubs by Race and Gender										
Male					Female					
African-American	Asian	Hispanic	White	Other	African-American	Asian	Hispanic	White	Other	Total
48	34	9	152	21	31	6	9	53	5	368
13%	9%	2%	42%	6%	8%	2%	2%	15%	1%	100%
		Total Male	264	72%			Total Female	104	28%	

Table 4: Demographic Data of the High School Clubs by Race				
African-American	Asian	Hispanic	White	Other
79	40	18	205	26
21%	11%	5%	56%	7%

Although this is the first year of the project, this seems to be a positive step toward addressing the problem of underrepresented interest in engineering and engineering technology.

NEAS+

The National Engineering Aptitude Search+ is a self-administered academic survey that enables individual students to determine their current level of preparation in applied mathematics, science and reasoning. The NEAS+ is an excellent mentoring tool and can also be used as an engineering club activity, as a school prepares for the TEAM+S program. Each school participating in the clubs have been provided a copy of the NEAS+ to administer to their students.

Practice Competitions:

Because the TEAM+S competition has never been held in the Charlotte, NC region, we are scheduling practice competitions for the participating clubs. High school students will work through half of the problems from a previous year's TEAM+S test so that they get an idea of what to expect at the competition at UNC-Charlotte (the competition was held on March 10th,

2004) The practice competitions are being held as a countywide competition. All teams will then advance to the official TEAM+S competition with a clear understanding of what to expect.

Other Competitions:

High school students love to compete and the purpose of the clubs is to immerse the students in fun and engaging hands-on engineering related activities to pique their interest in engineering and engineering technology. The project, therefore, encourages the club members to participate in a variety of competitions; each designed to highlight some aspect of engineering technology.

Robots:

Another of the competitions in which the club members will be participating is a robotic competition – a robot soccer game. To maintain a level playing field, all clubs have purchased the same robotics kit: The Lego Mindstorms Robotic Invention Kit.

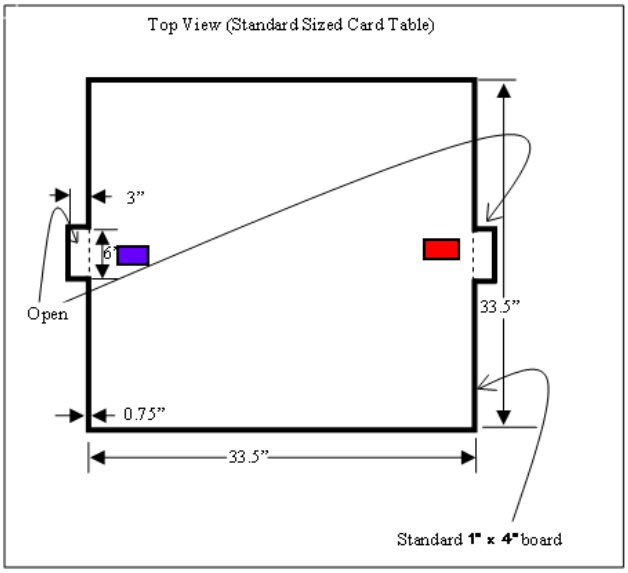

Figure 1: Robotic Competition Playing Field

The robots will begin in the locations shown in Figure 1 (designated by the red and blue rectangles). A rail, built with standard 1"x 4" lumber, will be used to surround the playing field, so that robots will not be in danger of falling off the table. The rail will be placed on a 33.5" x 33.5"Card Table. On each side of the playing field will be a goal 6" wide and 3" deep that will be open. Below the "goal" will be a bucket to catch ping-pong balls.

Two robots, from competing teams, will be placed in the playing field along with 20 ping-pong balls. The ping-pong balls will be placed randomly within the playing field. The robots will be given 2 minutes to gather as many ping pong balls as possible and then push them or drop them into their goal. The robot with the most ping-pong balls at the end of two minutes will win this heat.

The robot soccer game was designed to challenge the students. The Mindstorms kit has two "touch" sensors (simple limit switches) that can be used. Although cameras are available to interface to the Mindstorm Kit, they were not allowed for this competition. High school club

members wanted a “battle” for their robots. Because we are working through the public school system, we could not allow buzz saws, nail guns, flame throwers, etc., so we developed this scenario.

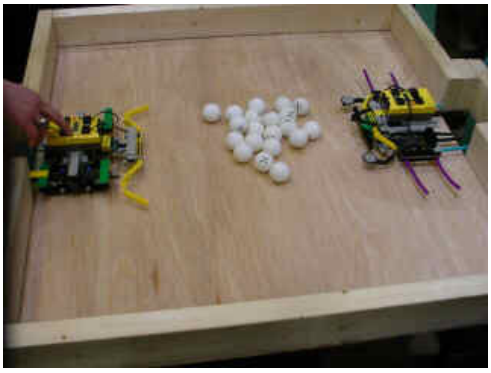

Figure 2a: Robots Ready for Battle

Figure 2b: Students watching the Robots

Students will have to devise a strategy for rounding up the ping-pong balls in a known area (see Figure 2a), but they will also have to deal with the uncertainty of another robot moving around in the same area. This problem has caused some unique solutions. This competition is to highlight some of the mechanical, electrical, and software engineering principals required in many engineering technology programs. The students enjoyed watching the robot competitions as they cheered their team (Figure 2b).

Trebuchets:

Were you aware that you trebuchet kits are available on the Internet? They are available with a simulator (see Figure 3) that helps the students understand the physics behind the fun. There is even a kit that will “toss a human” (this is not the one we plan on using with the high schools).

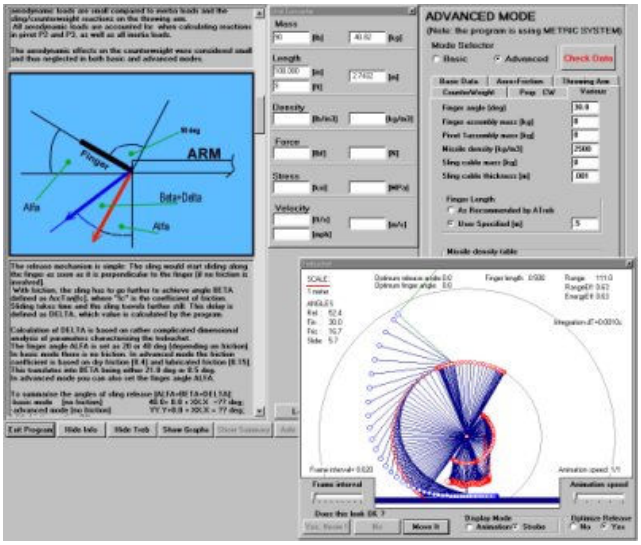

Figure 3: Sample Trebuchet Simulator (from Trebuchet.com)

Figures 4 and 5 show some example trebuchet kits. These can be purchased for relatively little money and built by high school students during club meetings. At the competition, student will

throw water balloons. They will also be allowed to design and build their own trebuchet. In this circumstance, they would spend more time with the simulation software to fine-tune their design.

Figure 4: Example Trebuchets (from Trebuchet.com)

Figure 5: Example Trebuchets (from Trebuchet.com)

There will be two parts to the competitions. The first will be a distance contest. The students who toss the water balloon the furthest will win. The second will test the team's accuracy in aiming the trebuchet. A target will be placed at a distance that most of the participating trebuchets can reach. The students will attempt to hit the target. Many of these high school students have suggested one small variation. They would like Steve (one of the authors of this paper) or their teacher to "be" the target. We are still working out the details on this suggestion.

This competition is to highlight some of the mechanical engineering fundamentals and the use of software as a problem-solving tool principal required in many engineering technology programs. The results of this and other competitions will be presented at next year's conference.

Writing and Speaking:

One of our goals through this project is to raise the awareness of high school students, parents, teachers, career counselors, and the community of the opportunities available in engineering technology disciplines. So, we've created a website with the relevant information, but how do we get the students and teachers to visit this site?

We will provide teachers and career counselors several workshops to raise their awareness of the career and educational opportunities for their students in STEM careers and college programs. We will also develop and train them in the use of an online advisement tools. But, we want to have the students research this information. So, we decided to host a "Writing and Speaking" contest.

Students will be given a specific topic to write about. It will include:

1. What are the differences between engineering and engineering technology?
2. What kinds of careers can you expect with an engineering degree? With an engineering technology degree?
3. What kind of salary can you expect?
4. What college will you choose? Why? Name two courses provided by this college's program that you are interested in. Describe the course.
5. What path will you take? Will you choose to enroll at a community college and then transfer to a university program or will you enroll directly in a university? Why? How much will this education cost you (or your parents)?
6. For the path you did not choose, what was it about this path that did not appeal to you?

The website will provide information for the students to begin their research and links to get them started looking at other sources. The students are then encouraged to thoroughly research their own answers to the questions. The high school students will then be asked to present their report to the other club members and to an additional class at their school. The papers will then be submitted to faculty at the university to be judged. The authors of the seven best papers will be invited to the university, along with their parents, teachers, and career counselors, to present their papers before a panel of faculty and industry judges..

So what's the carrot? How do we get the students to participate? First, second and third places will be awarded money as well as a certificate and trophy.

Bridges:

The students will also participate in bridge design contest hosted by UNC Charlotte.

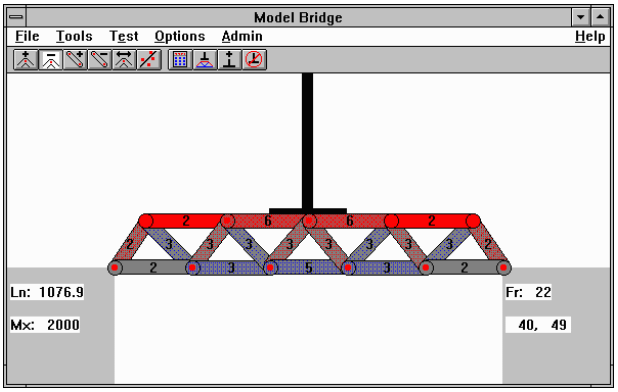

Figure 6: Bridge Design Software

This software and contest will highlight some of the civil engineering fundamentals required in many engineering technology programs. It will also demonstrate to the students how to use of

software as a problem-solving tool. The students will build the bridges they design and test them to failure. We are sure this is an activity that they will enjoy.

Summary:

With the imminent shortage of scientists, technologists, engineers, and mathematicians in our nation, it is crucial that the engineering community do a better job of attracting women and minorities to engineering careers. UNC Charlotte and its community college partners are determined to do what it takes to encourage these young adults to pursue careers in science, technology, engineering, and math. Through club activities and through interesting, engaging, and fun hands-on projects and competitions, students will be introduced into engineering and engineering technology in very creative ways.

In a survey taken at the March 10th competition, students told us that they have enjoyed being a part of the Engineering Clubs, enjoyed working with the robots, are looking forward to the trebuchets.

Table 5
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	58.9%	20.0%	21.1%

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.

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.

Only fifty-nine percent of the students indicated that they would join the clubs again next year. This statistic did concern us. We then realized that seniors were included in this data, but they would not be in high school next year to be involved in the club. When the seniors' responses

were removed we found that eighty-two percent planned on being in the club and sixteen percent were unsure (see Table 6).

Table 6 Results of Student Survey (Corrected for Grade Level)			
Statement:	Agreed	Not Sure	Disagreed
I will be in the club next year (All but Seniors)	82.5%	15.9%	1.6%

This most encouraging statistics are shown below, in Table 7.

Table 7 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.

Although this is the first year of the project, we feel that we are observing some positive trends and encouraging results. It is our hope that after the initial pilot program at UNC-Charlotte that similar programs be incorporated at other locations across the country, and that we are able to continue the momentum.

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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.

Leann Yoder has over 5 years of pre-college engineering education experience where she has served as both JETS' Director of Programs and Director of Marketing & Communications. Leann is very interested in developing programs and materials focused on getting young people excited about careers in engineering.