TECHNOLOGY CONNECTION-A PROGRAM FOR PRECOLLEGE ORIENTATION AND RECRUITING

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ABSTRACT

Recruitment of top-quality engineering students and orientation of K-12 students toward studies and careers in engineering are challenging tasks. One of the ways the Florida Atlantic University (FAU) College of Engineering is working to meet these challenges is through its *Technology Connection* (*TC*) summer program for middle and high school students and teachers. Now in its fourteenth year, the TC program has enjoyed many successes and has achieved widespread recognition for its efforts to cultivate and stimulate secondary student and teacher interest in science, mathematics, engineering and technology (SMET). Program goals and objectives, organization, activities, staffing, funding, and cost-benefits are described in this paper. Additional information is available from the *TC* web site at http://tcn.cse.fau.edu/homepage/tc.html.

INTRODUCTION

The *Technology Connection* program evolved around certain elements believed to be key to encouragement of students to pursue studies in engineering and computer science[1]. These elements include:

- Emphasis on the importance of studies in the prerequisite areas of mathematics and science.
- Ability to place mathematics and science concepts into the context of real world problems.
- Enhanced understanding of today's technological world.
- Opportunities to work with state-of-the-art equipment not available in secondary schools.
- Hands-on experience with engineering and computer science.
- Support of skilled, motivated teachers.

Technology Connection originated in 1983 as a small (12-15 participants) summer enrichment program for high school students. By 1992, the program had been extended to middle school students and the number of participants had grown to some 100-120 students each year. At that time, a teacher education and training component was added and the *Technology Connection* name was adopted. To date, some one thousand students and one hundred teachers have participated in the *TC* program.

[1] Computer Science is offered within the College of Engineering at Florida Atlantic University.

This paper begins with a statement of *TC* program goals and objectives, followed by an overview of how the program works for students and for teachers. Program details, such as typical laboratory exercises and design projects, staffing, funding, and cost-benefits, are considered next. A brief summary of experiences with the program concludes the discussion.

> *" I loved being able to build things with my hands; it was an experience I'll never forget. ... I'm thinking of changing what I want to be in life."*
>
> *"The facilities and faculty are superb and I learned a lot."*
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> *"I had a great time. Not only did it teach me many things, like how to make a web page – which I will employ at home as soon as I get a web page maker- it also allowed me to make new friends. I would definitely like to come back next year!"*
>
> ***TC 97 Student Participants***

TC GOALS AND OBJECTIVES

For students, the goal of *Technology Connection* is to encourage studies in mathematics, science, computers, and engineering. Naturally, the hope is that this will eventually be at Florida Atlantic University and in the College of Engineering. Experience shows that many students do just that. For teachers, the goal is to increase motivation, improve skills, broaden horizons, and provide opportunities to network with the FAU College of Engineering.

TC program objectives are to:

- Build connections between studies in mathematics and science and real-world technological problems.
- Provide exposure to ways mathematics, science, computers, and engineering are used in business and industry.
- Provide access to state-of-the-art computer and engineering laboratories of the FAU College of Engineering.
- Encourage teamwork and creative thinking through design projects and technical competitions.
- Provide students information and experience needed for reasoned educational and career decisions.
- Provide students a glimpse of campus life.
- Provide teachers new and meaningful opportunities to learn and to interact with peers.
- Build continuing partnerships with teachers and their schools.
- Insure full participation by women and members of under-represented groups.

Program goals and objectives are accomplished through a highly structured mix of hands-on laboratory exercises, industry tours, industry speakers, design projects and competitions, special activities, and social and sports events. Emphasis is upon hands-on applications of mathematics, science, computers, and engineering to real-world problems. Teamwork and creative thinking are featured. Student and teacher participants work together to achieve educational goals - a key, and truly unique, feature of the TC program.

TC FOR STUDENTS

Middle and high school groups of 50-60 students each reside on campus for five days. Middle school students attend one week and high school students the next week. Resources and facilities available determine the number of participants. Applications always exceed the space available. Current cost to students is $425, all-inclusive. Scholarships provided by industry ensure equal opportunities for all to participate.

Historically, 40% of the participants are women and 50% are members of under-represented groups. Most are from Southeast Florida. About 10% come from out of state.

Admission is based on a demonstrated aptitude and interest in mathematics, science, computers, and engineering. A letter of recommendation from a teacher/counselor and a personal essay are required. No specific grade point average or standardized test score is necessary. Student interest and motivation are the paramount considerations for admission.

Students and family members arrive on a Sunday afternoon for dormitory check-in and program orientation (Figure 1). This is followed by a family BBQ, campus tours, and evening social activities. The technical part of the program runs Monday through Thursday, 9:00 AM - 4:00 PM, with special activities or social and sports events in the evenings. A half-day typically is devoted to tours of industry. Design competitions and award ceremonies close out the program on Friday.

Fig. 1. *TC* Check-In

An experienced team of student counselors accompanies the students at all times outside of "class" hours. Counselors also arrange and manage evening events - pool parties, tennis, movies, etc. - and assist with design projects and competitions. Meals are provided by the campus food service. Arrangements for housing, meals, counselors, and transportation for tours are handled by the FAU Division of Continuing Education and Open University.

TC FOR TEACHERS

Teacher participants engage in a four-week program of education and training. Most are mathematics, science, or computer instructors living within commuting distance of Florida Atlantic University (Broward and Palm Beach Counties).

They receive three semester-hours of graduate credit for their participation, applicable toward recertification and/or graduate degrees in Education. A stipend of $2,000 is provided - half from their school system and half from a Grant funded by the Florida Department of Education.

The goal is to recruit a highly enthusiastic and motivated group of twenty teachers who will be effective agents of change, able to take ideas and knowledge gained from the *TC* program back

to their own classrooms and schools and to disseminate it to others. A letter of recommendation from their school and a statement of their interests and expectations for the *TC* program are required. As with student participants, interest and motivation are primary considerations for admission.

Prior to student arrival, teachers engage in an intense two-week program of education and training involving the same laboratories and exercises that will be used for students (Figure 2). Supplemental sessions on educational methods and curriculum design provided by the FAU College of Education help teachers place the technical activities experienced into the context of their own classrooms.

Each teacher is required to prepare a lesson plan based upon some aspect of *TC*, in accordance with the Florida Sunshine State Standards. Plans are shared among all participants. A teacher recognition luncheon hosted by the Dean of Engineering closes out this first phase of the *TC* program.

"What a great experience! I have learned so much that can only make me a better, more knowledgeable teacher."

"These weeks were full of new and exciting experiences, shared with a group of caring and friendly people. All of us had a common goal, which was to improve ourselves to benefit our students."

"I was so happy I wouldn't change anything. ... The faculty and staff are excellent!"

"Finally, because of TC, I have real answers to the eternal question – when am I ever going to use this stuff (mathematics and science)."

TC 96 and 97 Teacher Participants

The following two weeks, teachers assist with instruction of the middle and high school participants. This approach, believed to be unique to *Technology Connection*, has numerous advantages. Most importantly, it provides teachers an opportunity to enhance their understanding of the subject matter by teaching it to others and gives them a greater appreciation of the relevance of the material, concepts, and ideas presented.

Fig. 2. *TC* Teachers Participate in an Analog Electronics Experiment.

Teachers enjoy working with colleagues from other schools and with the bright students attracted to *TC*. In return, their assistance helps provide the high level of program staffing needed for student success in the short time periods available. Teachers also are invaluable in helping maintain discipline, order, and program schedules.

LABORATORY ORGANIZATION AND INSTRUCTION

Hands-on laboratory exercises are the heart of the *TC* program. Subjects, typically six in number, are selected to provide experience with a broad range of topics in mathematics, science, computers, and engineering. All academic areas of the FAU College of Engineering are represented.

Suitability for secondary students and availability of faculty and facilities are additional considerations in topic selection. Student and teacher evaluations from preceding years are weighted heavily in the selection process. One or two new activities are introduced each year. Previous activities of proven effectiveness are recycled, often with some modification for improvement.

Teacher participants are divided into two groups, with each group cycling through the same set of activities. Teacher laboratory activities typically run for 6-9 hours each, providing some opportunity for individual exploration and work.

Student participants are divided into four groups of 12-15 each. Each group cycles through the same set of laboratory exercises. Within each laboratory, students typically work in teams of two, ensuring individual access to equipment and facilities. The same exercises are used for both middle and high school students, with the instructional level adjusted accordingly. Student laboratories run for 3 hours each.

Laboratory sessions typically start with background instruction on the mathematics, science, and engineering principles involved, followed by application of these principles in laboratory and project assignments. All activities are designed to allow students to work to the levels of their individual abilities. Students who are more capable have some opportunity for independent exploration and work.

Instruction is provided by a carefully selected group of motivated Engineering and Computer Science faculty and graduate students, experienced in working with students at the middle and high school levels. Instructors are compensated at their normal rates of pay, prorated for a period covering class and preparation time. Each is provided a student assistant. Three or four *TC* teacher participants also are assigned to each laboratory. With this level of staffing, and careful planning, *TC* students can accomplish a great deal in the limited time available.

TYPICAL LABORATORY EXERCISES

Laboratory activities for the 1997 *TC* program are described below. Other topics that have been used include Finite Element Methods, Computer Aided Design, and Engineering Design. The FAU College of Education also presents a laboratory on Content Mapping for *TC* teacher participants.

***ELECTRONICS*:** Basic concepts of analog and digital electronics and the underlying principles of mathematics and science (Ohm's Law, binary and complex numbers, Boolean algebra, etc.) are introduced. Participants constructed a soundboard that creates a siren sound and observed pictures of the emitted sound on an oscilloscope. A counting circuit also was designed, built, and tested.

Over the years, a variety of exercises and kits have been used in this laboratory. The virtual laboratory software package, *Electronic Workbench*©, also has been used with good success. Use of this software provides exposure to computer simulation concepts. Most *TC* teachers do not have the facilities to replicate this laboratory with their own classes.

MECHATRONICS: Concepts of "mecha-tronics", a technology which integrates mechanics (motion) and electronics (control) to engineer products or machines with built-in intelligence, were introduced. Each participant assembled a sound-controlled "Scooter Bug" robot kit (Figure 3). Students operated their robots in a competition similar to “pinball”.

Fig. 3. A “Scooter Bug” in the Making.

Since its inception, this laboratory has always been the top-ranked *TC* activity. Several *TC* teachers have replicated this activity with their own classes. However, funding is a limitation for most teachers. The kits used cost about $20 each.

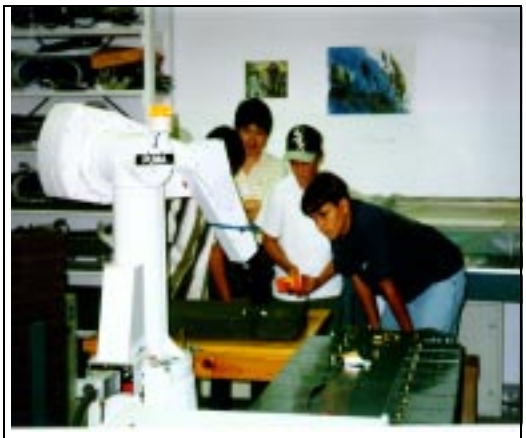

Fig. 4. *TC* Students Operate the PUMA Robot.

ROBOTICS: Participants programmed two different types of robots to simulate sorting, packaging, and assembly operations typical of those encountered in an automated factory (Figure 4). Different types of input sensors, including video vision, were involved. Participants also programmed a computer-operated milling machine to create individual wooden name plaques.

Mathematics and science topics covered include coordinates and graphs, mechanical motions, and optics. This laboratory often is followed by industry tours showing robots in action. A few *TC* teachers have purchased small robots for their own classes. Most make use of this laboratory through individual student projects directed by Engineering faculty or by bringing their students back to campus for tours and demonstrations. Over 1,000 students and teachers tour the FAU Robotics Laboratory each year.

TELECOMMUNICATIONS AND COMPUTER NETWORKING: This Laboratory featured the World Wide Web and HTML. Fundamentals of computer inter-networking, information retrieval from the Internet, net surfing, and Web authoring were covered. Creation of a personal Home Page was the project. Homepages created by teachers and students in this laboratory can be viewed at the *TC* web site at http://tcn.cse.fau.edu/homepage/tc.html.

This laboratory is very popular because of the cutting-edge technology involved, because of the creativity and freedom of expression possible, and because so many students have computers at home. Consequently, both teachers and students can replicate and build upon many of the things learned in this activity.

INVENTIVE PROBLEM SOLVING: Methods of systematic inventive thinking and problem solving were covered, including the Russian-developed TRIZ methods. Fundamentals of intellectual property (patents, copyrights, trademarks, trade secrets, and unfair competition) were introduced. Techniques featured in the laboratory have a wide range of application for all participants. This activity has been very popular with teachers because of the ease with which materials and concepts can be replicated in their own classrooms. The instructor has developed a unique set of large physical puzzles and other hands-on learning aids for this subject, also taught as a regular university course. Thousands have experienced and enjoyed the items created through displays and exhibits at local schools, libraries, and museums.

MULTIMEDIA: Basic elements of building multimedia applications were discussed. Participants learned how to create and incorporate various objects into multimedia presentations. Each group designed, developed, and presented a multimedia presentation consisting of video clips, animated graphics, images, and audio.

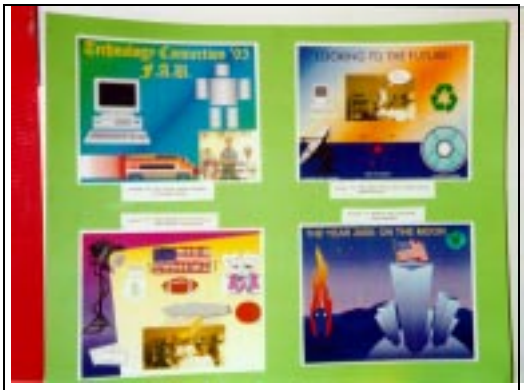

Fig. 5. Student Multimedia Posters

This very popular laboratory allows for lots of creativity and expression of individual interests. Projects have evolved over the last few years from creation of individual color posters with a science or technological theme (Figure 5) to full-fledged multimedia presentations. Another attractive feature of this laboratory is that it includes activities that teachers can readily take back to their own classes; many schools now have multimedia capability.)

DESIGN PROJECTS

An impromptu design competition is the grand finale for TC students. Student teams are given a bag of miscellaneous materials from which to create an object that will meet certain performance criteria. Teacher participants develop the project and arrange and manage the competition. Students spend much of their last night on campus working on their projects. Interest is high and local press coverage is good. In addition to awards for performance, a "best technical design" and "best aesthetic design" are selected and recognized.

Recent projects include:

- "TC-Scramble" - a vehicle to travel down an inclined track and across the floor, with its path obstructed by a small wooden block with a raw egg perched atop. Longest distance traveled across the floor without breaking the egg wins. Strategies devised include stopping short of the obstacle and swerving to avoid it. The winning team cleverly constructed a vehicle that "caught" and protected the egg when the block was struck.

- "Land Surfer" - a device to be propelled down a horizontal metal track by a box fan; a combination of fastest time and longest distance traveled win. More powerful fans were needed. Students improvised by adding their own huffing and puffing - Figure 6.

- "Marble Maze" - a maze for a marble constructed from a cardboard shoebox and construction paper. Longest (yes, longest) time for the marble to traverse the entire maze wins. The marble was required to enter the top of the box and exit through the bottom. Although very simple, this project was wonderful in terms of the creativity possible. The winning team created their maze outside the box.

Fig. 6. Huffing and Puffing was not part of the Design Plan!

TC PARTNERSHIPS

Partnering with others is an important aspect of *Technology Connection*; activities vary from year to year. Representatives from industry have spoken about real-world engineering activities and have discussed the importance of mathematics and science in preparing for careers in science and engineering. They also have led exercises in "teamwork" and "group communications". University personnel have provided student guidance on preparing for college and for studies in engineering.

Tours of local manufacturing facilities are common. Examples include Motorola (automated assembly of pagers), Sensormatic Electronics (manufacturing of anti-theft "tags" for consumer goods), and Pratt & Whitney (design and testing of rockets and jet engines). Tours are selected for their potential interest and for the ties they provide with academic components of the *TC* program. For example, laboratory exercises in robotics often are followed by a tour of Motorola or Sensormatic, where robots are heavily utilized in manufacturing and assembly.

Last year, the Ft. Lauderdale Museum of Discovery & Science participated in *Technology Connection*. Their staff taught very popular sessions on "Science in Sports" and "Plastics", supported by the hands-on exhibits available on the Museum floor. Teachers also received a "behind-the-scenes" tour of unique Museum facilities, such as the IMAX Theatre and Living Reef.

EVENING EVENTS

Evening events for students also vary from year to year. Aside from social and sports activities, there have been team building exercises, bridge-building contests, and short design projects and competitions. In one popular event, student teams prepared and presented a "commercial" for some aspect of mathematics, science, or engineering, which was videotaped in the University's Instructional TV studios.

TC COST-BENEFITS

With direct costs currently running some $100,000/year, *Technology Connection* is an expensive program. Is it worth the cost? For the FAU College of Engineering, the answer is a resounding yes!

About half of the costs are associated with the student component of the program, with the remaining half associated with the teacher component. Some three-fourths of the costs are covered by student tuition, donations from industry, and grants from county school systems and State agencies. The College of Engineering provides the remainder (primarily faculty and graduate student stipends).

Direct costs currently run about $500 per student, largely covered by the tuition of $425. Tuition has intentionally been kept as low as possible to increase program access. About one-third of *TC* student participants qualify for full or half scholarships funded by industry.

Program payoffs in terms of student recruitment are long term and difficult to quantify. Resources for collection and analysis of tracking data have not been available. Anecdotal experience shows that increasing numbers of students enrolling in the FAU College of Engineering are past participants in *Technology Connection*. This is particularly true for women and minorities. Percentages of female and minority engineering enrollments at FAU run well above national averages; *TC* definitely is a major contributor to this success. Students who have participated in *TC* generally do very well in their academic programs and quickly emerge as student leaders.

Information on *TC* students who later enroll at FAU in programs other than Engineering, or who engage in college-level studies at other institutions, is very limited. What data are available indicate that *TC* was a positive and influential experience for these students.

In terms of building connections with local school systems and the community, *TC* program payoffs are widespread and immediate. The FAU College of Engineering is widely known and much appreciated for the opportunities provided to middle and high school students and teachers through *Technology Connection*. Program interest and demand are high, with far more applicants each year than can be accommodated.

Additional benefits of *TC* accruing to the College of Engineering include graduate teaching productivity generated by the *TC* teacher participants and summer employment opportunities for Engineering faculty and students.

CONCLUDING REMARKS

Technology Connection has done wonderful things for the FAU College of Engineering and for the students and teachers served. Formal and informal surveys of participants, parents, and school system personnel indicate that program goals and objectives are being met. The idea of relying upon teachers to provide a multiplier effect for program efforts definitely works. Teachers use *TC* projects and activities with their own students, they bring classes to campus for tours

of Engineering laboratories and facilities, they use Engineering faculty to assist with class lessons and projects, and they become staunch advocates for the College of Engineering.

> *"I'm sure you all may wonder if the teachers in the program (TC) ever take back and use anything we learn through this program. Well, we do! I have incorporated many of the inventive problem-solving puzzles and brain teasers that we learned in my own classes. My students beg me for them."*
>
> ***TC 97 Teacher Participant***

Replication of the program by others, either in whole or in part, would be straightforward. However, a substantial commitment of time and resources would be required. Whatever is done, must be done well. Wide exposure associated with a program such as *TC* magnifies both successes and failures.

Activities and competitions should be structured so that there are lots of "winners". *TC* students and teachers go home with lots of certificates, ribbons, trophies, and things they have created. Instillation in the participants of a sense of self-accomplishment and a "can-do" attitude is crucial to program success.

Good faculty and staff, interested and experienced in working with students at the middle and high school levels, are crucial. *TC* is all about personal interactions (Figure 7). The *TC* team at FAU is enthusiastic about the program and the benefits it provides. Keeping their enthusiasm within reasonable and affordable bounds is a major management challenge.

Fig. 7. End of a Long Day in the Laboratory.

BIOGRAPHICAL INFORMATION

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SHARON M. SCHLOSSBERG – Dr. Schlossberg is Director of Engineering Student Services at Florida Atlantic University, with administrative responsibility for all pre-collegiate programs of the College. She is co-director of the TC program. Dr. Schlossberg holds an Ed.D. (Florida Atlantic U.) with specializations in Curriculum and Instruction and Guidance and Counseling. She holds two Master's degrees – one in Special Education and Education of the Gifted and another in Guidance and Counseling.