

An Overview of Space-Oriented Activities for Texas PreFreshman Engineering Program Participants in the El Paso Area

Scott Starks, Eric MacDonald

Department of Electrical and Computer Engineering
University of Texas at El Paso

Sally Blake

Departments of Teacher Education and Physics
University of Texas at El Paso

Abstract

Providing pre-college students with activities to enhance their understanding of science and mathematics can improve their preparation for the study of science and engineering at the university level. This paper presents a number of hands-on activities that are based upon space-related themes that have been conducted by participants in the El Paso Chapter of the Texas PreFreshman Engineering Program (TexPREP) over the past several summers. The hands-on activities grew out of a collaboration that was formed in 2001 between the El Paso Chapter of the TexPREP and the Pan American Center for Earth and Environmental Studies (PACES), a research center on the campus of the University of Texas at El Paso (UTEP). Because PACES receives support from the National Aeronautics and Space Administration (NASA), it was natural that activities with space-oriented themes be introduced as a means to stimulate student interest in science, engineering and mathematics. This past summer, the TexPREP program served over 300 participants from the El Paso area. This paper presents a description of these space-related activities and some results from the evaluation of the program.

Introduction

Over the past several decades, the need to increase minority and female participation in engineering has taken on added importance. An increase in minority and female participation in engineering is needed not only to help fill industrial positions, but also to create a diverse student body. The key to increasing minority and female participation lies in education¹. Young people need preparation in science and mathematics *before* they get into higher education – and before they begin flowing out into the workforce². If we want more females and minorities to take an interest in technological fields, we must create a more inclusive view of engineering and technology. The first step is to debunk the stereotype of the “computer nerd” by depicting the broad array of career options in science and technology³.

This paper addresses activities that have been conducted in the El Paso area through the local Chapter of TexPREP. As a bit of background, the 2000 US census reports that Latinos comprise 76.6% of the over 563,000 residents of the city of El Paso⁴. This vibrant community is, however, marked by high levels of poverty, unemployment and academic underachievement. In spite of recent gains nationally in mathematics and science achievement, there still remains a discrepancy between students of different demographic backgrounds. Asian Americans, Pacific Islanders and white students outperformed Black, Hispanic, and Native American Students – even when comparisons correct for the disparities in the courses students have taken⁵.

Texas PreFreshman Engineering Program

The purpose of the El Paso chapter of TexPREP is to identify high-achieving middle and high school students in the El Paso area with an interest in engineering, science, and other mathematical fields of study and to increase their knowledge of job opportunities in these fields. The El Paso Chapter of TexPREP is one of fifteen TexPREP sites that operate around the State of Texas. The statewide office is located in San Antonio⁶.

TexPREP is an academically intense eight-week summer program. It provides middle and high school participants with educational opportunities in Science, Mathematics, Engineering, and Technology (SMET) disciplines that transcend what are offered in the regular academic year. TexPREP activities are designed to stress the development of abstract reasoning, problem solving skills, and their applications. The program encourages the participation of underrepresented minority and female students. Securing financial support for the program is a major challenge and limits the ability of the program to reach more than the 300 students presently served. A student may participate in TexPREP for a maximum of three summers. Students are organized into three groups (Year 1, Year 2, and Year 3) based upon years of program participation.

Program Goals

The goals for El Paso TexPREP program are the following:

- To acquaint student participants with professional opportunities in engineering;
- To reinforce the mathematics preparation of these students at high school and college levels;
- To increase the number of competently prepared students from the El Paso area who will ultimately pursue engineering studies in college;
- To increase the retention rate of these students as they progress through college;
- To recruit participants from the school districts in and around El Paso with special efforts made to attract female students and students from minority groups who have been traditionally underrepresented in the professional engineering and high technology areas.

Program Curriculum Components

TexPREP provides a curriculum that seeks to better prepare its participants for future college studies. The bulk of the curriculum is centered in mathematics preparation and it introduces

topics that are not normally offered during the regular academic year. By completing all three summers of TexPREP, students will have received instruction in following subjects:

- *Logic and Its Applications to Mathematics*: A daily lecture class required of Year 1 participants.
- *Visual Calculus*: A visual, hands on approach to calculus concepts for Year 1 participants.
- *Algebraic Structures*: A daily lecture class required of Year 2 participants.
- *Introduction to Engineering*: A four-week daily lecture/laboratory class with topics in Engineering. This component incorporates design projects for Year 1 students.
- *Introduction to Computer Science*: A four-week daily lecture/laboratory class in writing computer programs. This component is required for Year 1 and Year 2 participants.
- *Topics in Problem Solving*: A daily, small group, seminar class for all participants. Problem solving was thematic based upon a “Mission to Mars” scenario and how TexPrep skills applied to it.
- *Research and Study*: Daily small group classes giving students time to work on class assignments, computer projects, or engineering modeling projects.
- *Introduction to Physics*: A daily lecture laboratory class with topic on physics and design projects in Physics required of Year 2 participants.
- *Technical Writing*: A daily writing class required for Year 3 students.
- *Statistics and Probability*: A daily lecture class required for Year 3 participants.

TexPREP/PACES Partnership

A theme expressed in NASA’s mission statement is “to stimulate the next generation of explorers as only NASA can.” The exploration of space is one of man’s greatest endeavors and can be used effectively to encourage students to study SMET courses. In 2001, a partnership was formed between TexPREP and the Pan American Center for Earth and Environmental Studies (PACES), a NASA University Research Center located on the UTEP campus⁷. The TexPREP/PACES Partnership was formed in an effort to strengthen the preparation of TexPREP students through their participation in “space-oriented” activities. The following sections introduce and provide a brief description of activities that have arisen through the TexPREP/PACES Partnership.

Remote Sensing

Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a sensor that is not in contact with the object, area, or phenomenon under investigation. Through a remote sensing activity, Year 2 students gained computer skills through their use of a commercial remote sensing software package, ER Mapper. They also gained an improved understanding of the electromagnetic spectrum and how it applies to applications such as remote sensing and image interpretation. The activity involved remotely sensed imagery of the El Paso-Ciudad Juarez border region and thus students acquired an increased appreciation of the geography, geology, and environment for the area in which they live.

Briefly stated, the project involved teams of 4 students who conducted a remote sensing project using Landsat TM data for the El Paso-Ciudad Juarez border region. Landsat TM data consisted of measurements in seven spectral bands in the range from 0.45 μm (blue) to 12.50 μm (thermal infrared) of the electromagnetic spectrum. Students learned the basic features of ER-Mapper, a widely used commercial remote sensing software package. Using ER-Mapper, students processed various Landsat TM files to produce “true” color and “false” color composite images. After gaining familiarity with the ER-Mapper software, teams of students began processing Landsat-TM data obtained from the El Paso-Ciudad Juarez border region. To begin, students produced true color images of the region. Using these “true” color images, students were asked to locate familiar landmarks in the image. Landmarks included airports, neighborhoods, parks, golf courses, and other physical and geological features. Often, these landmarks could not be easily located in the “true” color image. Next, students processed the Landsat data using combinations of bands that involve those in the visible range of the electromagnetic spectrum as well as bands in the infrared region. Using the resulting “false” color images, students were called upon to identify once again a variety of significant landmarks in the area. Through their observations, students learned the advantages of using the “false” color over the “true” color images for the purpose of identifying landmarks.

CricketSat Activity

In order to provide Year 3 students with an appreciation of the electronics, a project was implemented whereby they constructed a circuit called a CricketSat. The CricketSat is a low cost, fully functioning telemetry device. It allows students to experience actual data collection, recovery, and analysis⁸. The circuit is akin to the type of temperature measuring device that one might see onboard an actual spacecraft or rover. It incorporates a temperature sensitive resistor, known as a thermistor, an integrated timer circuit, a variety of passive components and a light emitting diode (LED).

At room temperature, the CricketSat’s LED pulses at a rate of approximately 2 Hz. The pulse rate is linearly proportional to temperature. Once their circuits were assembled by soldering, teams of students were given stopwatches and thermometers. They were asked to collect and record pulse rate data along with temperature at a number of sites around campus. Once data was collected, the students were asked to graph it and develop a mathematical relationship between pulse rate and temperature. This aspect of the project was valuable in that it allowed students to “discover” the linear relationship between pulse rate and temperature. It also brought real-life meaning to modeling the relationship between physical quantities using mathematics.

Protein Crystal Growth Experiment

For several years, the Texas Space Grant Consortium has sponsored a State-wide Protein Crystal Growth Experiment as a means for stimulating student interest in biotechnology and microgravity. This highly successful educational outreach program has engaged thousands of students and teachers from around the state. Through the Texas Space Grant Consortium, the Protein Crystal Growth Experiment was made available for Year 2 and Year 3 students.

The activity consisted of several components that will be briefly described. To begin, the advantages of growing protein crystals in the microgravity environment of space were explained. Students were divided into eight groups of four students each. Each group prepared super-saturated solutions of lysozyme, a protein found in human tear ducts, in mucous, and in chicken embryos. These eight solutions were distinguished by adding different amounts of salt, which acts as a precipitant, to each lysozyme-buffer solution. Each group transferred its solution to eight small culture tubes. The groups then traded tubes so that in the end each group had a crystallization screen comprised of eight different salt concentrations.

Students were asked to hypothesize about which salt concentration level they believed would produce the biggest crystals. Students made daily recordings of their observations of crystal size and prevalence. After two weeks of observations, students were instructed to draw conclusions and to write an essay about the activity. Each essay included a description of the experiment, their hypotheses, their data collection methods, and experiment results.

The essays were graded and the top twenty essays were identified. The twenty winning essayists were invited to participate to an actual flight sample loading that was conducted by technical staff affiliated with the NASA Marshall Space Flight Center. The flight samples were frozen so that they could then be flown to the International Space Station via the Space Shuttle. The twenty students were promised a trip to Cape Kennedy to witness the launch of their samples. Because of the recent grounding of the Shuttle fleet, the samples have yet to be delivered to space. However, the students still received VIP invitations to Kennedy Space Center.

Rover Design Competition

Year 1 students participated in a competition to design and construct a rover capable of traversing a desert terrain. The students were provided with a box of “Lego” robot parts from which they constructed their design. Students were also given two reversible 9-volt stepper motors with controllers. The wheels on each side of a rover could be turned independently using the motors. This enabled the rover to be turned and guided by the operator using a controller.

A competition was held to determine the overall best design. A track course was laid out that included a number of turns, elevations, and obstacles.

“Mission to Mars” Play

At the end of the summer, student participants wrote and conducted a play with a space theme. Special sets, props and costumes were designed and constructed. The play was designed to contain information about space and NASA that the students had learned through their summer experience with TexPREP. Students constructed a mock flight deck for their spacecraft. The play presented aspects of day-to-day life on a “Mission to Mars.”

NASA Field Trips and Guest Speakers

Experience has shown that field trips serve as a tremendous motivator for students to continue with the program from one summer to the next. For many participants, these field trips

represented their first venture beyond the city limits of El Paso. TexPREP has successfully integrated NASA into the field trips for Year 2 and Year 3 students. Year 2 students visited the Alamogordo Space Center, located approximately 120 miles from El Paso. At the Alamogordo Space Center, they toured the space museum and attended an IMAX movie presentation about space. Year 3 students visited Space Center Houston where they learned about the Johnson Space Center. As part of the tour, they experienced demonstrations and lab experiments concerning physics in space, thermodynamics, and other related topics.

Evaluation

In an effort to improve the effectiveness of the TexPREP program, an evaluation plan was developed and implemented for 2004. The evaluation plan consisted of the analysis and collection of data related to program completion; pre- and post-test performance; and participant attitudes and beliefs. Findings from the evaluation are summarized below. For a more complete treatment of the evaluation, the reader is referred to⁹.

Program Completion

There were 330 applicants for summer 2004. The interested reader is referred to the website⁹ for application requirements. Of these, 323 students were accepted and 293 students successfully completed the program. Of the 293 completers, there were 252 Hispanics, 22 Anglos, 7 African Americans, and 12 Asians. The group of completers was comprised of 129 females and 164 males. The completers can be broken down into 144 Year 1, 95 Year 2, and 54 Year 3 students.

The completion rate for 2004 was 90.7%. This compares favorably with the completion rate for 2003 which was 87.2%. We feel that the introduction of the hands-on activities described in this paper was responsible in some way to the high completion rate. Prior to the new millennium, the program did not have a wide variety of hands-on activities and the completion rate was significantly lower (approximately 70%.)

Pre- and Post-Testing

Pre- and post-tests are administered to all participants. Year 1 students are tested in logic; Year 2 students are tested in science; and Year 3 students are tested in probability. Each test consists of 20 – 25 multiple choice questions. Table 1 exhibits data relating to student performance on these tests. It should be noted that only students taking both the pre- and post-tests were included. High percentages of students from each Year improved their performance on the post-test (Year 1: 91.7%; Year 2: 97.9%; and Year 3: 94.4%.) Overall, 94.2% of participants improved on the post-test.

Participant Attitudes and Beliefs

Surveys related to participant attitudes and beliefs were administered to all participants at the end of the summer. Responses were solicited in an attempt to capture some degree of how effective

the program was in developing student perceptions and interests in science and engineering careers. Results of these surveys are summarized in Table 2.

Year 1 Participants	
Students Taking the Pre-Test	144
Students Improving on Post-Test	132
Year 2 Participants	
Students Taking the Pre-Test	95
Students Improving on Post-Test	93
Year 3 Participants	
Students Taking the Pre-Test	54
Students Improving on Post-Test	51
All Participants	
Students Taking the Pre-Test	293
Students Improving on Post-Test	276

Table 1. Pre- and Post-Test Performance.

The curriculum reinforced my mathematical skills.				
Agree	82.0%	Disagree	18.0%	
The program improved my problem-solving skills.				
Agree	71.4%	Disagree	28.6%	
The program increased my knowledge of math-based professions.				
Agree	88.6%	Disagree	11.4%	
The program reinforced my desire to study engineering, science or math.				
Agree	71.4%	Disagree	28.6%	

Table 2. Results of Participant Survey.

Though results in Table 2 are aggregated for all Year levels, data is available by Year level¹⁰. In general the survey results indicate that the participants did feel that the program had a positive impact on their mathematical and problem-solving skills. The students indicated that the program was particularly effective in increasing their knowledge of math based professions. There is a low level of “high-tech” industry in the El Paso area. We feel that field trips and guest speakers were particularly effective in acquainting students with math-based occupations.

Conclusions and Future Plans

We are encouraged by the positive results of the evaluation for TexPREP. Over the past five years, the number of students participating in TexPREP has more than doubled. Other evaluation data reveal that the overwhelming majority of participants go on to college and many eventually earn degrees in SMET areas. Considering the high percentage of underrepresented minorities and females in the program, we feel that this is an important achievement.

We intend to continue to incorporate NASA themes into TexPREP activities and curricula. Of the components described in this paper, we found that the CricketSat and the Protein Crystal Growth Experiment generated the highest interest and motivation among students. We do plan to experiment with new space-related activities. One activity that is planned for summer 2005 is one that centers on the construction of a Solar Powered Golf Cart. There are numerous golf carts that are operated by the Building and Grounds and the Athletics Departments on the UTEP Campus. We will draw parallels in this project to those of NASA rovers operating on the Moon and Mars. Students will gain an appreciation for solar energy, green engineering, and space exploration through this project.

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SCOTT A. STARKS

Dr. Starks currently serves as Professor of Electrical and Computer Engineering and Director of the Pan American Center for Earth and Environmental Studies, a NASA-sponsored University Research Center. He has research interests in soft computing, signal processing and engineering education. Prof. Starks is a registered Professional Engineer in Texas.

SALLY BLAKE

Dr. Blake currently serves as Associate Professor of Teacher Education and Physics at the University of Texas at El Paso. Also, Dr. Blake is the Director of the El Paso Texas PreFreshman Engineering Program as well as the Associate Director for the Partnership for Excellence in Teacher Education and the Noyce Scholars Program. She has research interests in mathematics and science education, educational reform, and minority education.

ERIC MACDONALD

Dr. MacDonald currently serves as an Assistant Professor of Electrical and Computer Engineering at the University of Texas at El Paso. He previously held positions as an engineer at IBM and Motorola designing microprocessors. In his last assignment at IBM he worked with the Research Division on an ultra-low power initiative. His research interests include VLSI, low power design, Design-For-Test (DFT) and engineering education.