Engineering Technology Challenge-Linkage with K-12 Education

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Abstract

The College of Engineering at the University of Texas at San Antonio (UTSA) and the Bexar Chapter of Texas Society of Professional Engineers (TSPE) formed a partnership to sponsor and host the Engineering Technology Challenge (ETC) for San Antonio area high school students over the last three years. The goal of this project is to increase high school students' interest in the field of Engineering and Technology. The event held annually in early April, involves three design challenges: ETC Robotics, Eggonaut Launch, and Junk Drawer Design. This paper explains how the College of Engineering works with the Bexar Chapter of the TSPE to sponsor this event. It describes the details of each challenge and how designs are judged and scored. The development of the program and challenges for hosting such an event are presented in the paper.

Introduction

In 2002, the Bexar Chapter of the Texas Society of Professional Engineers approached the College of Engineering with a proposal to establish an Engineering Technology Challenge (ETC) contest for high school students in the San Antonio area. The goal of the proposed project was to increase interest among high school students in pursuing careers in engineering and technology. Since this proposal was in line with the mission of the University, the College of Engineering enthusiastically agreed to partner with TSPE in creating and hosting the ETC contest annually.

It was decided that TSPE would take the lead in the organization and publicity of the event, while the College of Engineering would be responsible for providing space for the contest, and encouraging faculty and students to support this event in technical areas and judging the contest. Shortly after the initial meeting TSPE formed an organizational committee to begin work on the project. The committee consisted of several engineer volunteers from the Bexar chapter of TSPE and volunteers from the UTSA College of Engineering community (students, faculty, and staff). The initial task was to select competition topics and developed guidelines for the events. The first year's categories of competition included: Web Site Design, Bottle Rocket/Eggonaut

Launch, and the ETC project. In February 2003, TSPE-Bexar sent each high school in the San Antonio area a package containing guidelines for the competition in each category and invited high school students to participate and compete in the ETC events. The first year's event was scheduled on Saturday, April 5, 2003 at UTSA. The competition allowed up to four teams from each high school and each team could have up to 4 members from grades 9-through 12.

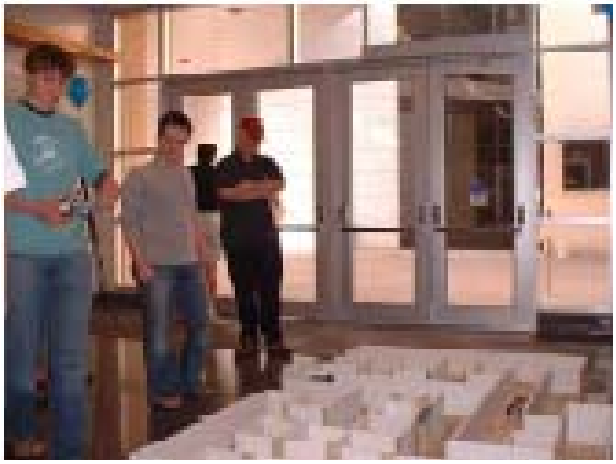
The Bexar chapter of TSPE has provided financial support for publishing and providing the parts and materials needed for the various categories of the competition. The College of Engineering provides logistical support for the competition and offers scholarships to the winners of the competition.

Areas of Competition

For the past three years, high school students in the San Antonio metropolitan area have had an opportunity to compete in three different ETC areas. A total of four (4) categories have been attempted for the ETC competitions as described below.

ETC Robotic
For this event students use the LEGO® MIND-STORMS™ Robotic Invention Systems to design and program a self-guided robot to travel through two mazes in the shortest time possible. Each team is required to submit a brief report discussing their design and the procedure used in testing the robot.

Upon registration each team is loaned a LEGO® MINDSTORM kit along with the diagram of Maze 1. The diagram of the second Maze is not provided until the day of the event. Teams must construct their robot using only the kits loaned to them. No additional materials will be allowed to construct the robots. The size of robots is limited to a maximum length, width, or height of eight (8) inches. Robots must be fully constructed, programmed and in working order by the day of the event. Students are given access to Maze 1 on weekends prior to the competition.



On the day of the event, each team is allowed one trial run of Maze 1. The teams are randomly selected to run their robot through Maze 1. If the robot completes Maze 1 within 5 minutes, the team will qualify for Maze 2. Each qualifying team is allowed two trial runs of Maze 2. The robot should be programmed in such a way that it stores the dead ends in its memory while exploring the Maze 2 during the first trial. The time for the first trial of Maze two is limited to five minutes. Those teams who are successful through the first run within the time limit will advance to the second run. In the second trial, the robot should travel through the maze as quickly as possible using the data stored during the first trial. The time for the second trial should not exceed five minutes.

Scoring
Teams are scored on their report and the time taken for their robot to go through mazes. A score is determined for each of the three trial runs. A maximum of 100 points is possible for each trial. If a robot completes a run within the 5 minute time limit, then it is given points based on the following formula.

$$\text{Points for the trial} = \frac{\text{Lowest trial time for the event}}{\text{Team trial time}} \text{ x } 100$$

Therefore, the team with the lowest time for each trial will be awarded 100 points. All other teams will be awarded points for each trial based on how their time compared to the team with the lowest time. A maximum of 50 points are awarded for the reports. The team with the highest total score of all three trials and the report will be determined the winner. In the event of a tie, the team with the lowest time in Trial 3 will be the winner.

Eggonaut Rocket Launch
For the Eggonaut Rocket Launch challenge, students design, construct, and lunch an air-pressured vessel containing a fresh egg, requiring the vessel to land on the ground with the egg intact and unbroken. The instruction given to students consists of the following guidelines.

A 2-liter clear-plastic (not green) soft drink bottle with an opening of 21 mm internal diameter must be used for the "fuel" compartment of the rocket. The opening will act as the rocket nozzle which, when the rocket is mounted for launch, will be at the bottom of the rocket. Only a combination of compressed air and water (fuel) is allowed to power the rocket launch. The teams must determine in advance the amount of water to be used during the launch. The rocket fuel compartment will be compressed with air to 80 pounds per square inch (psig). No other source of potential or kinetic energy is allowed for launching the rocket.

The rocket design should include a cone attached to the fuel compartment, capable of containing one raw, large grade "A" chicken egg. The egg is provided at launch time and loaded into the cone. Fins may be attached to the fuel compartment, but they must not protrude more than 40% of the total length of the fueled section and may not extend below the bottom of the rocket nozzle. Rockets will receive points on an aesthetic evaluation.

Teams must submit a short report on the day of the competition. The report should contain scaled drawings of the rocket during the design phases, materials used, procedure used in construction, a list of modifications to the rocket during the design phase and why each modification was made. A paragraph should be included to list and explain Newton's three laws,

as well as how each law pertains to the rocket. The report should also include comments on the reasons the predicted results may not be the same as the actual. The results from the computer program modeling, including the three graphs from each model, should be included as an appendix. A score for the portfolio will be given to each team.

Students submit their rockets and reports as they sign in on the morning of the event. The rockets are given back to the teams at the launch site. Compressed air and water are provided for the launch. Team members will fill the bottle with water and a judge will assist the team in attaching the rocket to the launch assembly. A judge will supply the rocket with air to 80 psig. At that point, the judge will instruct a team member to activate the launch. Flights are timed from launch to the moment of cone landing. If the egg separates from the cone, the time will be taken when the egg lands. Each team is allowed two launches.

Scoring
Each launch evaluation is based on the rocket's flight time and the condition of egg upon landing. The score for launch is calculated using the following formula:

> (the number of seconds the rocket spends in the air) x 2
> plus
> (25 points if the egg is unbroken, 10 points if the egg is cracked, or no points if the egg is broken at the end of flight)

In addition, each team may receive a maximum of 20 points for their report and 10 points for aesthetic condition of the rockets. The highest score from both launches will be used and added to the scores from the report and aesthetic evaluations. The winner will be the team with the highest score. In the event of a tie, the winner will be chosen based on the rocket with the lowest mass, not including the egg or water.

Junk Drawer Design
This event requires teams to design and construct a vehicle using various small household items given to them on the day of the competition. A partial list of specific items that will be used during the event is provided to students in advance. For example, the 2006 competition announcement states that the following materials will be provided on the day of competition: Styrofoam blocks (2 - approximately 2"x2"x3"), tape (¾ inch, Scotch Magic Tape or equivalent), string, pencils, rubber bands (variety of sizes), playing cards, latex gloves, aluminum foil, glue (Elmer's Glue), and thread. However, several other items will be added to the supplies on the day of the competition.

On the day of competition, at least one piece of each material provided to the teams must be used in the construction of vehicles. The teams can use only the materials provided to them to construct their vehicle. Teams must complete the design, construction, and testing of their vehicle within ninety minutes. Teams must prepare and submit a report outlining the design process the day of the competition.

Prior to the event, teams are selected at random in the order in which they will compete. Each team will set up at the starting point and when instructed will activate their vehicle. After the

vehicle comes to a complete stop, the judges will measure the distance traveled and the distance deviated from a straight marked path to the center of the vehicle. Each team is allowed two attempts.

Each team must prepare a short report that outlines the team plan of action on the day of competition. The reports should include a narrative of design theory and process (explaining how the energy is stored and released to power the vehicle), construction process, modification plan (anticipating what additional materials will be provided during the competition), testing plan, and plans to make the vehicle aesthetically attractive.

Scoring

Each trial run will be evaluated based on the distance traveled and distance the vehicle deviated from a straight line. Vehicles must travel at least 10 feet to qualify for points. The scores for qualifying runs are calculated using the following formula:

$$\text{Points for the trial} = \frac{\text{distance traveled x 2}}{1 + (\text{distance deviated from straight line})}$$

where, the distances are measured in feet. Three (3) judges will review and score the presentation of topics in the report. Charts, drawings and sketches will play a significant role in the scoring of the report. The 3 judges' scores will be averaged to determine the report score. The highest score from both trials will be used and added to the score for the report to determine the winner. In the event of a tie, the winner will be chosen based on the team with the lightest vehicle.

Web Page Design

The event was a part of the first year's competition and was eliminated from the ETC events the following year. For this event students were challenged to design a web site that specifically pertained to science and/or technology. The contestants could be individuals or teams of no more than three students. Any web design software could be used for this event as long as the final product could be viewed with Internet Explorer. The web site had to have an index page, a minimum of two (2) others had to be accessed from the index page, at least one (1) link to another web site, and a minimum of three (3) graphic images or photographs.

Scoring

The website was evaluated and scored by judges. Each web design could receive a maximum of 100 points based on the following distribution: Overall design of the web site including layout, grammar and graphics (40 points), functionality/effectiveness of the web site (40 points), usefulness of information provided within the web site (10 points), and oral presentation of the web site and theme (10 points).

High School Student Participation

Eighty nine (89) high schools in the San Antonio metropolitan area have been targeted for the ETC events. Over the past three years 16 different schools have participated in various ETC events. Annual student participation has been in the range 110 to 165 students (38-54 teams). Currently, the participation in the ETC Robotics project is limited to 12 teams since only that many number of LEGO® MINDSTORM kits are available to be loaned to students. However, there is plenty of room for growth in the other two competitions, especially, the Eggonaut Rocket Launch project. The Junk Drawer Design event draws the largest number of participants. These events have challenged student in several areas of engineering and technology and indications are that students have had fun participating in these events.

Recognition and Scholarships

All students participating in the ETC events receive a certificate of recognition. In addition, the UTSA College of Engineering awards 10-12 "Dean's Scholarships" to the members of the first place teams in the ETC competition. The scholarship awards are based on the conditions that the recipient applies and receives admission to UTSA, declares a major in one of the programs in the College of Engineering. The $2,500 scholarship is distributed in the amounts of $500 per freshman, sophomore and junior years and $1,000 during senior year.

Planning

The organizational committee meets several times during the year to plan for the ETC events. After each year's competition, the committee evaluates the success of each event and changes or makes modifications to prevent difficulties encountered during the competition. For example, in the second year, the Web-Site Design competition was replaced with the Junk Drawer Design challenge. The 2005 categories of the competition were the same as those in 2004, but the guidelines for each category were modified to improve the competition process.

During the first two years of the competition, only the Eggonaut Rocket Launch project required the submission of a detailed report. As a result, few teams entered this event and most teams participated in other ETC projects. It became clear that some the teams entering events that required no report put limited effort into preparation for the competition. Therefore, starting with the 2005 competition, the committee decided to require a brief report for all ETC events which resulted in a sharp improvement in the quality of designs entering the competition.

The committee also reviews and improves the guidelines for the competition on a continual basis. For example, the new guidelines for the 2006 Eggonaut Rocket Launch competition

requires the implementation of a computer modeling program for the rocket. Students can download the Water Rocket Fun (v3.4) from a web site[1] onto most operating systems including Mac and Windows free of charge. They are instructed to run at least three models in the program while varying water percentage, temperature, extra weight and drag. The results must be included in the report with the graphs (pressure vs. velocity, height vs. time, and rocket velocity vs. time) from each run placed in the appendix.

Between May and December, the committee's efforts are focused on the review and modification of events while planning for the April competition. The guidelines for the events are finalized in December. A package that includes a brochure, guidelines for each of the ETC events, and examples of score sheets are sent to all high schools in the San Antonio metropolitan area. A cover letter is included in the package inviting high school students to participate in the events. This information is also posted on the Bexar Chapter of TSPE web-site[2]. A promotional video taped during the 2005 competition was also included in the 2006 package.

From January to April, the committee works on the details of the operation and the logistics for the competition. These efforts include the recruitment of students and faculty to assist in running and judging the events on the day of competition. The committee meets a couple of times with all volunteers in March to make assignments and answer any questions. Also the UTSA police department and the physical plant are contacted for parking arrangements and to ensure that no problems exist on the day of competition.

The committee has considered expanding the competition to include students from middle school and increase the number of events. The ideas for new projects include bridge contest, paper art plane, build water filter, and retaining wall project. Currently, the committee is evaluating the financial resources and manpower requirements for expanding the ETC projects.

The Bexar chapter of TSPE initially spent $2000 to purchase of LEGO® MINDSTORM kits. The annual cost of ETC operation has been approximately $5000, which includes the mailing cost, purchase of material, advertising, and other miscellaneous items.

Acknowledgements

The implementation of the ETC projects required the contribution from many volunteers. Some of the contributors have spent many hours to develop and refine the ETC events. We would like to acknowledge the contribution of all volunteers, especially those listed below. Haggar Alsaleh, Alberto Portillo, and Kimberly Cornet have lead the development, refinement, and implementation of the Lego Mindstorm. Patrick Dow and Abel Guzman served as the leaders and coordinator of the Eggonaut Rocket Launch project. The Junk Drawer Design was developed and refined by Jason Scheppers, James Higdon, and Joel Johnson. Monica Ramos has been in charge of publicity and Becky Culpepper has served as treasurer and secretary. Paul Carter served as UTSA liaison and played an essential role in arranging the logistics at UTSA for the competition days. Several other members of the engineering community, UTSA students and faculty have served as volunteer judges and guides for the events. Pape Dawson Engineers, Inc. and UTSA have supported the ETC projects by providing space for meetings and competitions.

References

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Biography

AMIR KARIMI
Amir Karimi is a Professor of Mechanical Engineering and an Associate Dean of Engineering at The University of Texas at San Antonio (UTSA). He received his Ph.D. degree in Mechanical Engineering from the University of Kentucky in 1982. His teaching and research interests are in thermal sciences. He has served as the Chair of Mechanical Engineering twice; first between 1987 and 1992 and again from September 1998 to January of 2003. Dr. Karimi is a Fellow of ASME, and holds membership in ASEE, ASHRAE, AIAA, and Sigma Xi. He is the ASEE Campus Representative at UTSA, ASEE-GSW Section Campus Representative, and the Chair of ASEE Zone III. He chaired the ASEE-GSW section during the 1996-97 academic year.

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J. Kent O'Brien, P.E. is a Vice President of Transportation at Pape-Dawson Engineers, Inc. He earned his Bachelor of Science degree in Civil Engineering from Texas A&M University in 1983 and has been practicing as a Professional Engineer since 1988. Mr. O'Brien currently serves on the Texas Society of Professional Engineers (TSPE) Board of Directors as the Bexar Chapter Representative, TSPE Nominating Committee Chair, Member Services Committee Chair and is a member of the State TSPE/CEC/TxDOT Liaison Committee. In the Bexar Chapter of TSPE, he has served on the Board of Directors since 1998 as President, Chapter Program Director, Secretary and on numerous committees including 4 years as the Bexar Chapter Engineer's Week Committee Chair. His memberships also include NSPE, ASCE, and the Tau Beta Pi and Chi Epsilon Engineering Honor Societies. Mr. O'Brien has directed the Engineering Technology Challenge since its inception. He has served on the College of Engineering Advisory Board at UTSA.