Chemically Powered Toy Cars: A Way to Interest High School Students in a Chemical Engineering Career

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Introduction

College recruiting events can be disheartening for chemical engineering faculty. Large numbers of students wait to talk to the science faculty about majoring in Chemistry, while very few consider Chemical Engineering other than as a respite from the crowds. Those few that stop to visit have one question: What is chemical engineering? Visiting with high school chemistry teachers, one realizes that their teachers are equally baffled by chemical engineering. If chemical engineering departments are to attract top students to join their ranks, they must educate the high school teachers as well as their students.

National engineering organizations have long recognized the value of holding competitions for gaining publicity and interesting students.[1] The American Society of Civil Engineers has held the National Concrete Canoe Competition since 1988. Regional competitions have been held for forty years. The International Society of Automotive Engineers began their best known competition, the Mini Baja, in 1976 and currently hosts six different competitions each year. In recent years, the American Institute of Chemical Engineers (AIChE) has initiated a Chem-E-Car competition that has been very well received.[2] Student teams build shoebox-sized cars which must carry a variable load of water and travel a distance that may vary between 15 and 30 m. This contest was duplicated in Australia at the World Congress of Chemical Engineering.[3] Many schools, including the University of Nevada at Reno and The University of Tulsa, have used a variation on this competition to improve student retention.[4]

At The University of Tulsa, the faculty recently initiated a new program designed to introduce chemical engineering to high school chemistry classes. Chemistry teachers and science club advisors in the Tulsa area were invited to enter teams to compete in a chemical-powered car competition, a modification of the AIChE Chem-E-Car Competition. The Tulsa Competition appealed to the chemistry teachers that entered teams because their students could apply the chemistry they have learned while requiring little mechanical expertise on the part of the teacher. The event was held on The University of Tulsa campus with judging provided by students and local industrial representatives. An informal atmosphere allowed the high-school students to interact with practicing engineers and college-level engineering students while they learned more about the university and chemical engineering as a career.

Objective

The goals of the Tulsa Competition were simple:

(1) To get the high school students onto The University of Tulsa campus and into Keplinger Hall to see the newly modernized chemical engineering laboratories.
(2) To introduce the students to chemical engineering as a career.
(3) To involve the best recruiters among practicing engineers and current students.
(4) To establish contacts with the high school chemistry teachers.
(5) To provide a technical activity for the high school students that would be fun.

Planning

The Tulsa Competition was scheduled late in the spring semester; however the first notice to teachers and science club advisors was sent out early in the fall semester. The teachers needed time to work this activity into their curriculum and, in many cases, to make arrangements for a class field trip. The announcement letter was mailed to all public and private schools from the metropolitan Tulsa phone book as well as to the Tulsa Home Educators Coalition, which serves as a clearinghouse for information of interest to families that home-school. If individual teachers were known, the letter was personalized. In addition to mailing the letter to schools directly, the letter was sent to the science chairs through the central distribution system of larger school districts. The announcement letter briefly described the competition, gave important time and place information, and enclosed the competition rules. For schools close to the university, teachers were invited to schedule a classroom presentation at their sites about The University of Tulsa's AIChE Student Chapter Chem-E-Car designs. A second announcement letter was sent out in January, about one month before the registration deadline, reminding the teachers of the opportunity. The first letter was intended to let the teachers begin considering our event in their planning for the next semester. The second letter served to remind the teachers of the opportunity and of the registration deadline. Both announcement letters referred to a website set up for the competition: www.ce.utulsa.edu/CarCompetition/index.html. This website included the announcement letter, rules, registration form, selected pictures of The University of Tulsa's Chem-E-Cars, and links to the sites for learning about other universities' Chem-E-Cars.

The rules for the Tulsa Competition were simplified from those used in the original competition held each fall at the AIChE Annual Student Conference. Specifically, the rules were adapted from those used in the fall of 2002.[2] All changes in the rules were designed with two primary purposes: (1) to minimize the emphasis on the mechanical design of the car as the coaches would be high school chemistry teachers, and (2) to modify the rules so that the competition could physically fit into Keplinger Hall on The University of Tulsa campus.

A major modification of the original AIChE competition rules was to provide a small car chassis kit to all teams.[5] This chassis (see Figure 1) was much smaller than those typically used at the AIChE student conference competitions which allowed for a much smaller facility for the competition. Although teams were not required to use the provided chassis, the cars had to be smaller than axle and wheelbase lengths defined by the kit car. An additional advantage was that the chassis was relatively simple to build with normal household tools. This eliminated some of

the mechanical difficulties encountered in building these cars and allowed the teams to concentrate on the chemical aspects of the competition.

Figure 1: Car chassis built from Daytona 400 kit.[5]

The car kit also included a simple (optional) motor. Teams were allowed to use an electrochemical reaction to power the motor if they chose. AIChE rules do not allow commercial batteries as the power source; however high school teams were allowed to use commercial batteries as the power supply *if* another controlled chemical reaction was used somewhere in the car to start and stop the motion. This allowed a greater variety of reactions to be considered. The students still needed to control a chemical reaction, which was a primary purpose of the competition.

The second major modification was to build a track for the competition. According the AIChE rules, the course is a wedge. The car starts at the point of the wedge, and the finish line is an arc 15 to 30 m from the point. Unfortunately, the only long, straight stretches in Keplinger Hall, the home of chemical engineering, are hallways and the bottom floor of an atrium, all of which are covered with a textured rubber flooring. The texturing makes it impossible to keep a small car rolling in a straight line. Building a track meant that the event could be held in the building on a uniform racing surface. By adding small walls to the track the cars could be directed in a straight line, eliminating wheel alignment as a problem. Since the cars were

smaller and space tighter, the track length was reduced for competitions ranging from 20 to 45 feet.

Since the competition was held in a classroom building, teams were allowed to release only gases or water from the vehicle. Several cars in the AIChE competition ran on CO_2 produced from acetic acid and baking soda and often sprayed a solution containing an excess of either acid or base. For safety and aesthetic reasons, this was not allowed.

The AIChE competition actually has two variables that are announced at the competition: the distance and the water load. The students then calculate reactants based on the calibration curves they prepared using the variables. To simplify the Tulsa Competition, the water load was eliminated.

Additional, minor rule modifications included changes to the allowed time for each team to compete, the cost of the cars and the registration procedures. The high school teams had seven minutes (rather than three) to get to the starting line, introduce their car, and complete their run. The run time itself was a maximum of two minutes. These changes were to compensate for the lower experience level of the high school students. The maximum permitted cost of the car was $200 rather than the AIChE limit of $1000. With current budget cuts, $200 was daunting. Although a car chassis and motor kit were provided, the school still had to provide any bottles, batteries, or other wiring they chose to use on the car. Finally, the registration form did not require information about the chemical reaction or propulsion system. This allowed the team to select their reaction in the two months between the registration deadline and the actual competition.

Since this competition was intended to be educational, several changes were made with respect to team formation and ethical conduct. In the AIChE competition, faculty and graduate students may act only as sounding boards. In this event, teachers or advisors could assist the students with ideas (including specifying which reaction to use). This allowed the teachers to better integrate the project into their curriculum. The design and construction of the cars was to be done primarily by the students. As with the AIChE competition, it was required that there be at least five members on a team. An entire class might be a team, and the entire team did not need to attend the competition. To allow for flexibility in forming the teams, there was no requirement of different grade levels on the team, as in the AIChE rules.

AIChE places the responsibility of safely transporting chemicals on the university students. The *high schools* were responsible for safe transport of the chemicals to the Tulsa Competition. The university provided for disposal of generic acids, bases, and solvents on campus, and the high schools were responsible for disposing of other chemicals.

The competition consisted of three separate competitions: poster, creativity, and distance. Poster and creativity winners received $100 each. The main event was the distance competition for which first, second, and third places were awarded $300, $200, and $100, respectively.

The University of Tulsa's Department of Chemical Engineering funded the event, as it was considered to be a recruiting tool for the department. Other potential sources of funding were the department's industrial advisory board, the local AIChE Chapter, the student AIChE or ΩXE Chapter, alumni, and local industry. The total budget for this event was $1,658, as delineated in Table 1.

Table 1. Cost for the Tulsa Chem-E-Car Competition

Item	Cost
Postage	$45
20 Car kits	$113
Track	$500
Prizes	$800
Lunch	$200
Total	$1,658

Selecting a Site

Since a goal of this event was to introduce students to Chemical Engineering at The University of Tulsa, holding the activities on campus was a priority. Several sites on campus were considered. At a minimum, the site needed to have room for both the poster competition and the distance competition. Access to running water was required for chemical safety reasons. Space for all participants along with adequate parking was also considered.

Outdoor locations were considered, but an indoor location was preferred because of weather considerations. Additionally, most large outdoor surfaces, such as tennis courts, are rounded for rainwater runoff. Sidewalks and parking lots are rarely level and have texturing that may cause problems with wheel alignment.

Indoor spaces considered included the basketball arena, a ballroom in the student activities center, and the unit operations laboratories. The basketball arena has an ideal floor with ample seating overlooking the floor. Unfortunately it is not close to Keplinger Hall and would have to have been scheduled around other events. In addition, chemical disposal facilities were not readily available and the building managers were leery of chemicals on their floor. Other gyms on campus had similar problems. The student activities center has a large ballroom and is located right across the street from Keplinger Hall. This ballroom had problems similar to those of the basketball arena: scheduling, chemical use, and chemical handling. The unit operations laboratory has adequate floor space for the competition with some rearranging. Chemical bench space is easily accessible, but crowd room is very limited.

The final option was the atrium of the Keplinger Hall. Chemical facilities and classrooms for the poster competition are nearby. Students could watch the distance competition from upper levels of the atrium. Since the building is located at the edge of campus it was easy to find and ample parking was available within one block. Most importantly, students had the chance to tour the department while there. High school students were able to see the new control room and unit operations laboratory facility, see lectures and laboratories in action and meet with students and faculty. A pizza lunch was served and one of the larger lecture halls was used for an awards presentation.

In order for the cars to operate successfully inside the building, a special track was designed. The carpentry shop at the University's Physical Plant built the track. The track was approximately two feet wide. The floor of the track was plywood, and the side rails were angle iron. A cross-section of the track is shown in Figure 2. The angle iron was used to hold the different sections of the track together. The track was built in sections to allow for easier storage. The plywood joints were spliced together and sanded to provide a smooth transition between sections. The cost of 60 ft of track was $500. The track was tested with a similar competition in the freshmen chemical engineering class before it was used for the high school competition.

Figure 2. Cross-sectional view of the track.

The Event

Judges were needed for the creativity, poster, and distance competitions. Other volunteers were needed to run the event. Sources of judges and volunteers included the faculty, university students, particularly AIChE or ΩXE members, the department's industrial advisory board, local AIChE chapter members, and local alumni. Using engineers from outside of the university freed up time for the organizers and gave high school (and college) students an opportunity to interact with practicing chemical engineers and find out more about career opportunities.

Volunteers were needed to be sure that all teams could find the competition and that the event ran smoothly. Some of the tasks that need to be done included:

- Setting up the track
- Preparing tables for posters
- Supervising the storage and disposal of chemicals
- Greeting students and judges
- Queuing teams as they prepared for their run
- Introducing teams during the competition
- Timing the teams' setup and run
- Measuring the run distance relative to the finish line
- Posting the results
- Giving tours of the facilities
- Setting up a refreshment area
- Cleaning up during and after the event

In addition, a primary contact and media contact and several "gophers" were available at all times.

The local media had been very supportive of previous engineering competitions. A press release and a tip sheet were sent out just before the event by University Relations to local TV stations and newspapers. In the past reporters and cameras have covered many College events. This was very important in promoting the university and chemical engineering to the general public and had the added advantage of letting teachers and students that did not participate see what they missed. These teachers may choose to participate next year.

Concluding Remarks

Many school districts are experiencing severe budget cuts. These cuts affected the teachers' ability to schedule field trips late in the semester, when the competition was scheduled. In the second announcement letter it was emphasized that the entire team (the entire class, in some cases) did not need to attend the competition. If a small group could come in one car, this eliminated the expense of a bus. For winning teams that could not be fully represented at the event, faculty went to the school to present the prize money to the entire class.

Methods of assessing the success of the event have been discussed. Tracking the number of participants from one year to another will indicate whether the event was valuable to the participating teachers. Surveying the students that participate to find out their intended major then surveying their teachers in the fall to find out what the students that have now entered college selected as their major will aid in assessing whether the event succeeded in making Chemical Engineering an attractive choice to the high school students. Finally, keeping track of the participants and comparing this list to the list of applicants to The University of Tulsa, the College of Engineering and Natural Sciences and the Department of Chemical Engineering will indicate whether this has been a successful local recruiting method.

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