Using Strategic Partnerships to Deliver Reality-Based Education

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Abstract

Meeting our nation's needs for trained individuals is the responsibility of our educational institutions. Engineering education continues to face criticism by industry for not producing students with relevant problem-solving experiences. Instructors are faced with providing such experience for their students while the political trend today is to reduce funds for higher education. Motivating students using abstract, hands off, assignments that students perceive as having little practical application in the real world is a challenge. This challenge can be resolved through a self-funded, reality based, hands-on experience that can motivate students and provide focus for the instructor.

Faced with these challenges, the instructors of the sustainability class at The College of Technology Architecture & Applied Engineering at Bowling Green State University (BGSU), Bowling Green, Ohio, searched for a class activity that would also meet the above challenges. In their search, the instructors concluded that the objectives of the evGrand Prix program had the potential to fill the need. The evGrand Prix competition requires students to field an electric racer and participate in a series of events that include wheel-to-wheel racing, efficiency runs, technical reports, and public outreach activities. The program requires students to organize as teams, fund, design, build and race electric powered racers. In the class, the students are given individual sub-projects to design and build the racer according to specification and to conduct the outreach campaign.

This article reports the experience of three separate classes of students, both in building the industrial partnerships and the results from the evGrand Prix projects conducted over a three-year period. The article also shares the author's mixed success in achieving the class goals. This has application for continuing the program and for other instructors who may be considering using similar extracurricular experiences in their classes.

Introduction

The College of Technology Architecture and Applied Engineering (COTAAE) at Bowling Green State University in Bowling Green, Ohio, offers the baccalaureate degree in engineering technology and graduate degrees in technology management [1].

The faculty of the college recognizes a national need to reduce energy dependence, maintain clean air, and create jobs for Americans. To meet this need, the faculty developed curricula in sustainable technology. It is also clear that there is a demand for

ISBN 978-1-60643-379-9

electric-powered vehicles that requires trained personnel to design, build, and maintain them [2, 3].

The COTAAE has a tradition of providing up-to-date, hands-on education for students. This is becoming increasingly difficult considering the trend toward reducing public funds to higher education, keeping tuition costs from risingm and reduced funding from private donations and industry grants in the current economy [4]. To counteract this trend, hands-on experiences in technology education nationwide are being replaced with computer simulations and online programs to reduce costs [5, 6].

Nationally, industry has been calling for educational reform because they find today's graduates lack experience and creativity. Articles as far back as 2009 attest to the fact that many new workers lack collaborative work-group experiences that prepare them for idea sharing. Industrialists are calling for learning environments where people of different ages and skill sets work together to solve complex problems [5-7]. James Plummer, dean of Engineering and professor at Stanford, provides a list of attributes that engineering students need including such things as undergraduate research, teams work/participate in competitions, etc. [7].

Determined to overcome the financial difficulties, meet the challenges of industry and the mission and goals of the COTAAE engineering technology program, the authors searched for an activity for their sustainability class. The activity should involve problem solving, have team and individual focus, provide real deadlines, and be a reality-based enterprise that can motivate and focus participant effort, include public outreach and demonstration, and address national needs and goals. It should also be funded by strategic industrial partnership, provide up to date equipment to the educational process and provide experience with latest electric vehicle technology. After considering a number of alternative activities, the authors decided that the reality-based, collegiate evGrand Prix program would best fulfil their needs.

The evGrand Prix Program

The evGrand Prix program, started in 2010, uses intercollegiate motorsports competition as motivation to develop and showcase electric vehicle technology and performance, increase public awareness and acceptance and relevant technical training for personnel. The evGrand Prix events are open to organized student teams from any post-secondary institution. The evGrand Prix program provides the basic specifications for the racer and event rules. These cover safety, fairness, cost and venue and event management [8, 9].

The program requires students to organize themselves in teams, in order to fund, design, build and race electric powered racers. The evGrand Prix Intercollegiate competition judges the participating teams in four categories of wheel-to-wheel racing, educational outreach, technical report and energy efficiency.

The educational outreach category focuses on educating the public at large about electric vehicle technology. It consists of producing marketing/advertising materials, exhibiting, demonstrations and seminars. Vehicle design and development work is documented in a technical report that is submitted for evaluation. The event is held at the Indianapolis Motor Speedway. The student built machines were put to the test in wheel-to-wheel 30-

mile races travelling at speeds nearing 50 miles per hour. The efficiency of the racer was evaluated during the race using data from on board required recorders.

Winners are awarded in each of the four categories. The champion is declared as a result of the finish in all categories. Though bragging rights came with a first-place finish, the authors consider that the real winners are the students who choose to compete and bring their racers to the starting line.

The Course and the evGrand Prix Project

ENGT 3250 Sustainable Technologies is a 3-credit hour class and forms part of the Engineering Technology curriculum. The class consists of two components: classroom based and a hands-on project based laboratory. In the classroom students learn about such technologies as re-cycling, green design, and green building, among others. The class is taught through lectures, field trips, guest speakers, and small self-discovery assignments. The class, though open to all university students, is primarily taken by engineering technology students with a mechanical technology design emphasis.

The goal of the project portion of the class is for students designing, building, fielding and promoting electric vehicle technology, and develop industrial partnerships for funding. Secondary learning objectives included gaining experience in project management, team work, verbal and written communication, in designing and manufacturing engineering products, and conducting undergraduate research.

One of the authors divided the project in to subtasks that could be conducted or a group of 2 to 3 students, and these reflected the vehicle and team equipment specifications [9] provided by the evGrand Prix and tasks deemed necessary and would make the difference in vehicle performance and help the team field the racer. The students were given the choice to select a topic of their interest. After reviewing their choices, some changes were made to ensure that all the essential tasks could be completed. No guidelines or specifications were provided for the 2011 outreach competition, so the instructional team formulated a list of objectives and requirements for the students to follow. These guidelines were adopted in subsequent years by the evGrand Prix program. As in the design, completion students were given a choice. In 2012 topics for the outreach group included: flyers and marketing materials development, developing display and coordinating outreach events, STEM activity development, developing an eV demonstration program, website master development, and media relations. There were 17 students in the 2011 class, 17 in 2012 class, and 20 in 2013 class. Figure 1 shows the 2013 design and outreach teams.

In addition to the class, student members of the BGSU Motors Sports Club were responsible for fund raising and working closely with the class students for purchasing of parts, and marketing partner relations. following project management procedures the instructional staff made a list of milestones that showed the dates by which some of the work had to be finished. These were based on some of the shows and exhibitions occurring in the area and also the evGrandPrix events. These were posted both electronically on ‘Blackboard’ and as paper calendars in the main meeting room. The project was conducted in the Electric Vehicle Institute (EVI), housed in the college.

Students worked independently on their individual subprojects under the supervision of the instructional team. Students were also encouraged to consult with vendors and industry experts. They were instructed on how to find materials and learn about technical areas with which they were not familiar. Students working on the technical element

Figure 1. The 2013 outreach and design teams instructors and drivers

designed and specified the needed components and fabricated many of these using the shop equipment available in EVI. Fabrication of some components was outsourced to local workshops primarily where safety, complexity, or meeting of deadlines necessitated it.

Similarly, students working on the outreach element designed their materials and had some of these made by involving students from the Visual Communications Technology program in the COTAAE.

EVI personnel and some of the motorsports club student members had been working to raise funds or seek in-kind donations from industry partners. Consequently, the class students had the opportunity to work with the latest technologies such as lithium ion batteries and AC motor drive. Enerdal Battery Company provided the batteries and grants from the BGSU Green Fund, and City of Bowling Green Utility fund are three examples of such partnerships.

Figure 2 shows names of the 12 major partners supporting the team efforts. Smaller contributions from alumni and private individuals rounded out the funding. No tuition or institution budgets were used.

ISBN 978-1-60643-379-9

Figure 2. Some of the sponsors and other organizations involved

Each lab session started with a short meeting, where students reported any problems they were encountering and reviewing the upcoming milestones. This allowed others to help with suggestions or even resources and kept everyone informed about the overall progress. This provided teachable moments where all students learned from one another. Figures 3 to 9 illustrate many of the hands on activities conducted and some of their results. As the semester progressed, each student kept weekly logs and updated a Gantt chart, which were used by them to write the final reports and the final project report and served as a project management tool.

Figure 3. Student working with motor controller

Figure 4. A student working with batteries

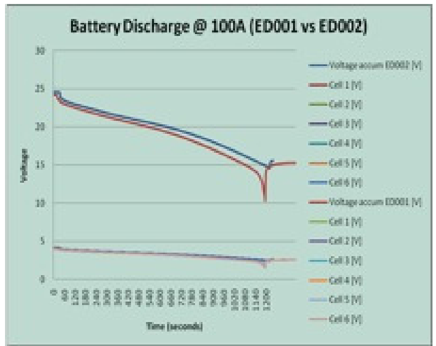

Figure 5. Results of the battery charging/discharging experiment

Figure 6. Students working on modifying the motor

Figure 7. Student designed and built battery exchange system

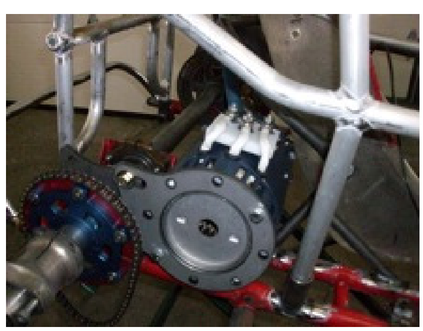

Figure 8. Student designed and built motor mounting and drive system

Figure 9. After first test of racer at Fremont

A volunteer team of students were ultimately selected to travel to the final event and represent the institution. Several were involved with the logistics of the trip to Indianapolis. Drivers and crews were trained. This required much planning and securely stowing the racer and other equipment in the truck used to transport the equipment. The travel team also made several test runs and practiced pit stops, tire changing and battery charging. The same team was responsible to setup and present the outreach and design exhibits at the speedway and worked as the pit crew.

Results

Through the research and development process, the students built a racer with specifications shown in Table 1.

Funding and Cost of Racer

The cost of building the first racer amounted to $13,000. Additional funds were used to complete outreach, design and travel commitments. A large portion covered the cost of advanced batteries. This investment can be used and prorated over several years of competition, which lowers the cost to field the racer next season.

As mentioned above, a key point is that the motorsports students did the majority of the fundraising by partnering with various organizations. Cash and in-kind (product) donations for 2011 totalled $21,000. Similar funding was secured for the prior and later seasons by the efforts of students and faculty advisors.

Table 1. The racer specifications

Electric Motor	38 Hp peak rated, 14.5kw (allowed) 3 phase induction
Motor Controller	Rated 0-80 Volt Out, 48-80 Volt In, 0-300 Hertz, 400 amps, operated at 48 volt nominal.
Chassis – kart based	Wheel Base – 40.5” :Front Tread Width- 36” Rear Tread Width-49” :Direct Chain Drive Eco Friendly MG Race Tires
Energy Storage	3 battery packs, 8640 watt hours/race Lithium Ion. Energy .213 gge/race (gas gal equiv)

Featured Outreach Efforts

Over the semester, the 2011 outreach effort reached a documented 10,000 people through partnering with other local colleges, vocational schools and racing clubs. The most notable of the sustainability class student efforts were the presentations made to post-secondary school groups. Other efforts included vehicle shows, visits to BGSU Electric Vehicle Institute, STEM workshops, and working with the local adult vocational school automotive class on building an electric vehicle. In the latter, the BGSU students guided the vocational students as they began to build a second electric racer copying the design of the first one being built by the BGSU students. Figures 10 to 15 illustrate some of these activities.

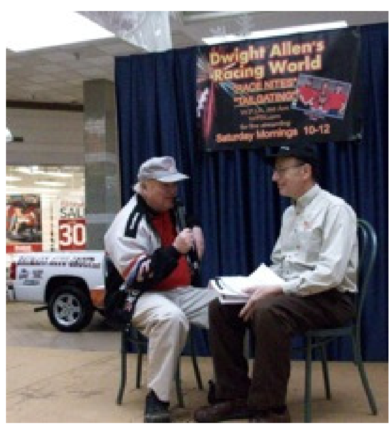

Figure 10. Radio show at a racing show in Bowling Green as part of outreach.

Figure 11. Display at Woodville Mall show as part of outreach

Figure 12. BGSU students demonstrating features of racer to Penta Career Centre students.

Figure 13. Display at junior high school as part of outreach

The Race

A total of 50 student teams entered the 2011 evGrand Prix competition at Indianapolis Motor Speedway (INDY). Of the 50, only 30 teams (60%), representing 10 post-secondary institutions including two teams from the UK, managed to bring their racers, technical report and outreach documentation to the international competition. Figure 14 shows the team at the Indianapolis motor speedway, and Figure 15 shows the BGSU racer setting up a pass during the race. Table 2 shows the results of the races in 2011, 2012, and 2013.

Figure 14. Crew at the Indianapolis speedway

Figure 15. BGSU racer (#9) setting up a pass during race

Discussion

Meeting the Objectives

The project met all of the original objectives stated above. The students had solved real problems, and used their previously learned skills and education to design and build their electric racer. Students gained experience working alone and in teams, learning the value of communicating with others.

They experienced how a project is managed including what must be done to meet deadlines and what happens when deadlines are not met. This could only have been realized in a reality situation with an ultimate deadline.

Since the project involved many facets, the students saw how projects benefit from multidisciplinary interaction. In this case, it involved mechanical, electrical, marketing and fundraising dimensions.

The problem of reduced funding, and consequent inability of educational institutions to expose the students to latest technology was also solved. For example, the students gained the opportunity to work with latest types of batteries that were donated and the other costs were born by the raised funds.

In addition, longer term relations with industrial partners were established. This later became a resource for continued funding and internship opportunities.

Students often had to interact with vendors of parts and work to meet the specifications provided by the evGrand Prix. They had to design (invent) parts for the racer. The outreach students had to plan with external exhibitors and schools and had to work on logistics of organizing the events. All these activities are examples of activities carried out by engineers in industry. Hence, clearly this project was a reality-based project.

The experience also proved the advantage of working as a team to achieve a goal. The competitive events and ultimately performance success and awards achieved by the BGSU student teams over the three years of participation shows they measure up to their peers from other institutions. Most important the students experienced individual success and failure as a direct result of their individual ability and commitment. This is a hallmark of reality-based

Table 2. Results of the races in 2011, 2012, and 2013

Year	Results
2011	• 2nd fastest in posted qualifying speed • Ran in first three places during most of the race. • Completed 7-second pit stop, fastest in competition. • Finished 8^{th} in race as a result of a late in race mishap with slower racer. • First Place in Educational Outreach Competition
2012	• 2nd and 8th place finish in race • 1st place in Outreach Report competition • 3rd in Design report

education. Finally, it can be concluded that the evGrand Prix experience provided the challenge and opportunity that it was designed and expected to do. Regardless of team success in competition, educators seeking a training tool or method must evaluate how the experience affects and helps the development of individual students.

Observations

As in any learning situation, some students were highly motivated. The committed students from the class and volunteer (not for credit) students from the Motor Sports Club, regardless of personal situation, stuck with it and gained the most from the experience. These typically were the students that became the members of the travel team that raced and presented at Indy.

Some students were not interested in electric vehicles or racing but most performed adequately in both lecture and project activities, some did not. Some students could not see the relevancy of building an electric racer to technical problem solving, while others could not see the correlation of the lecture topics on sustainability to the project side of the class even though the instruction was carefully orchestrated to include examples.

In a few cases, there were students who were failing the lecture component of the class and yet were top performers on the project side. The average students found the project component to be challenging. Some simply were not prepared to give the time commitment required. Being a reality-based project, some project topics demanded reliance on other students completing their tasks on time. Students were susceptible to the vagaries of external agents such as the vendors and part suppliers. This often necessitated the students to work outside of ‘normal class time’, which many found difficult. This difficulty was exasperated by the fact that many of these students worked part-time in other jobs to earn money. Other students scheduled an “overload” of classes attempting to graduate early to try to save money in the long run. Some students simply could not handle the rigor and discipline required to complete a project. Some were simply overwhelmed. It was also surprising to the instructors that some juniors and senior students had simply not written a technical report or failed at using the Internet to look for technical materials.

From the faculty instructional delivery side, there were also some difficulties. Though teachable moments present themselves continuously in the program, the students need to have access to a smorgasbord of expertise when they are ready. This expertise is typically not found in one individual, which required more than one faculty member or community volunteer to mentor and guide the students. In this case, some faculty members who had the expertise could not or would not participate in helping the students. In these situations, volunteers from the community provided much appreciated help to the instructors. This level of volunteer commitment is difficulty to sustain and rely upon by the instructors. It is simply not in the educational budget for the college administration to staff this activity over long period of time using paid faculty or college staff and the likely hood to persuade reluctant faculty members to incorporate such an experience into their classes. So the problem soon becomes increasing the level of external funds to help cover support personnel.

As in any partnership, both parties gain. Some of the ways the industrial partners gained were credit for philanthropy, access to technical students not only within the project but also through internships, confidential product testing with feedback, access to new markets through name recognition via media, shows, and other venues.

Conclusions and Recommendation

It was obvious that the reality-based program magnified some of the student inadequacies that were being seen by industry. The best news is that these problems can be seen while the students were still enrolled at school. The news is only good if we can somehow find a way to treat the inadequacy prior to a student starting an internship or receiving a degree. Though reality based programs similar to the evGrand Prix provide all that has been advertised, the 3 year experience of the authors show that these capstone experiences are most valuable as an extracurricular supplement to the normal educational program. Some effort needs to be placed on encouraging students to participate in these programs by the faculty. Another possibility is to require a for credit capstone experience as a substitute or requirement prior to an internship and graduation. Because of high visibility events and needs of industry, these programs may be self-funding giving some consideration for modest student scholarships to be awarded. Faculty may continue to find value in carefully incorporating specific problem topics from such programs in structured classes.

In the final analysis, these become issues for discussion at-large between lawmakers, industry and the educational institutions, as to how to sustain these activities and meet the needs of developing the type of engineering technology graduates that the industry has been calling for. It is likely that more study will be needed before the problem is solved and that some form of reality-based or capstone experience can help.

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