Intercollegiate Motorsports Competition as Motivation to Develop and Showcase Electric Vehicle Technology and Performance, Public Awareness and Acceptance and Technical Training of Personnel

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Abstract

The College of Technology at Bowling Green State University, Bowling Green (BGSU), Ohio, offers courses on sustainability. It also houses the Electric Vehicle Institute (EVI), a research and development organization for electric vehicle technology research and development and provides a workspace for the extracurricular BGSU Motorsports team. This paper focuses on an electric vehicle educational program. It describes how the authors incorporated the reality based, collegiate evGrand Prix program into both classroom and extra-curricular activities in one of their classes and reports on the achievements of the students as a result of building an electric competition vehicle. The evGrand Prix program 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 program consists of a series of events that include wheel-to-wheel racing, efficiency runs, technical reports and presentations and public outreach activities. The class participated in all these events and therefore the class required students to organize into teams, fund, design, build and race racers powered by electricity. The other major requirement was to develop materials such as posters and brochures for the public outreach activities. The racer and the outreach activities were showcased at an international collegiate competition held at the Indianapolis Motor Speedway in May 2011. The student team received 1st prize in public outreach activities and finished 8th in the wheel-to-wheel racing in group of 25 nationwide competing teams.

Keywords: Battery Electric Vehicles (BEV), Public Education, Demonstration, Marketing, Training, Job Creation, Public Awareness, Vehicle Performance, Sustainability, evGrand Prix, Motorsports Education.

1 Introduction

Bowling Green, OH, offers Baccalaureate degree in Engineering Technology and Graduate degrees in Technology Management. The stated mission of the college is;

"Consistent with the vision of Bowling Green State University, the College of Technology aspires to become the premier technology institution in the Midwest. Our mission is to develop technical and design professionals for leadership roles who are adept at the application of technology, responsive to change, innovative in problem solving, and skilful in the communication concepts." [1]

The College houses programs in Engineering Technologies among others and also the Electric Vehicle Institute (EVI). The faculty of the college recognizes national need to reduce energy dependence, maintain clean air and create jobs for Americans. To meet this need the faculty is developing a focus in sustainable technologies, by creating relevant curricula. It is also clear that in order to help meet these above mentioned national need, electric propulsion systems are being applied to vehicles in hybrid and plug-in electric configurations. Consequently there is a need that consumers must understand the benefits of owning and operating electric driven vehicles. This demand for electric powered vehicles requires trained personnel to design, build and maintain them.

The COT has a tradition of providing up to date hands-on education for students. This is becoming increasingly difficult due to the increasing trend toward reducing public funds to higher education, and reduced funding from industry in the current economy. This is a general problem in technology education and so hands on experiences in schools are being replaced with computer simulations. Furthermore, there are increasing pressures from colleges' administrations to provide on-line education in order to reduce costs, which further reduce the opportunity to provide hands-on experiences to the students.

The Electric Vehicle Institute at Bowling Green State University was started in 1994 to provide research and development services to industry who were interested in building and marketing electric propulsion systems that were modelled after the successful "Electric Falcon" all electric formula lightning racer shown in figure1.

The College of Technology (COT) at Bowling Green State University (BGSU) in

Figure1. All Electric Falcon Electric Racer circa 2003

The EVI mission is to develop and promote advanced electric propulsion technology and transfer these technologies to appropriate corporations and public agencies for production and implementation. Over the years, the institute has conducted nearly 2 million dollars of research which resulted in several patents, products and papers which have contributed to contemporary electric vehicle products such as shown in figure 2. This shows a shuttle bus being used on the BGSU campus.

Figure2. Electric Hybrid Bus Project circa 2002

In addition to research projects, the institute provides support and work area for the BGSU motorsports team and student class projects related to electric drive systems.

1.1 National Need for Change

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 come together to solve complex problems. "Innovation is a set of clinical practical disciplines and you can only learn them…. by actually doing them." [2]

A senior project engineer was quoted in a later article, published in Electronic Design Magazine in 2011, that "Students coming in the field have far too little hands-on experience with technology… computers and the internet have replaced technical hobbies…" industrial arts programs are being eliminated… "…many students have no idea how anything is actually made" [3]

The same article reported that students complained about being subjected to outdated textbooks, teaching materials and techniques, two few labs and a general lack of funding. Students interviewed said:

- "A major issue at my university is budget… One or more labs for classes have been cancelled giving students less opportunity to try their hand at what I would call real-world engineering".
- "Students do not have a firm grasp on what engineering covers do not get the most from their classes. … What are some practical applications where you would see an example of this?"
- "Companies….expect you to have some experience in the field."
- "I wish I had done an actual design…rather than talk about the process"
- "I wish we were taught why things are done the way they are instead of how they are done."[3]

James Plummer, Dean of Engineering and Professor at Stanford put it this way, "engineering students need:

1. To learn their discipline in depth and broaden their education in areas beyond math, science and related classes.
2. To learn how to innovate and be creative.
3. To learn entrepreneurship.
4. To learn how to work in a diverse team.
5. Undergraduate research programs in a faculty lab or related setting.
6. to participate in student competitions
7. Global knowledge and experience.
8. Communication skills.
9. Life-long learning programs, such as online courses and free lectures.
10. To know why engineering is important. "[4]

1.2 Meeting the need

Determined to overcome the financial difficulties, meet the challenges of industry, meet the mission and goals of the College of Technology at BGSU and the engineering technology program, the authors searched for an activity for their Sustainability class that:

1. Involves problem solving
2. Has team and individual focus
3. Provides real deadlines
4. Is a reality based enterprise that can motivate and focus participant effort.
5. Includes multi-disciplines and allow the students to apply their knowledge and skills
6. Has potential to be self funding and affordable while allowing for multiple participant teams
7. Provides experience with latest electric vehicle technology
8. Has academic rigor requiring writing and communication
9. Includes public Outreach and Demonstration
10. Addresses national needs and goals
11. Provides up to date equipment to the educational process

Originally a number of different areas of sustainable technologies were considered for the project. These included; Electric Vehicles, Alternate fuels, Recycling, Water Harvesting, Energy Management and Audits, Wind Energy and Solar Energy. Finally only Electric Vehicles was found to address all the requirements and could utilize the expertise and facilities available in the Electric Vehicle Institute. The authors decided to incorporate this as the reality based, collegiate evGrand Prix program.

3 The evGrand Prix program

The Electric Vehicle Grand Prix was launched in 2010 as part of Purdue University's electric vehicle initiative. Purdue partnered with leading technical universities and colleges in Indiana to establish a program to educate and train the workforce needed to design, manufacture and maintain advanced electric vehicles, and formed the Indiana Advanced Electric Vehicle Training and Education Consortium (I-AEVtec). This organization has now proliferated into the

evGrand Prix Consortium which includes BGSU and technical universities and colleges throughout the nation and abroad. [5]
The evGrand Prix program 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 are opened to organized student teams from any post secondary institution. The evGrand Prix program event is designed to inspire college students to pursue careers in electric vehicles and sustainable technologies by studying and applying Science, Technology, Engineering and Mathematics (STEM). The evGrand Prix encourages students to pursue these fields of study on a national level. The evGrand Prix program provides the basic specifications for the racer and event rules. These cover Safety, Fairness, Cost and Venue and event management. [6]

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 2011 events were held at the Indianapolis Motor Speedway. The Race was run for 30 miles on a one third mile road course. 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 which is submitted for evaluation. The efficiency of the racer is evaluated at the race. 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 come 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 grid.

4 The Course

ENGT 3250 Sustainable Technologies course is a 3 credit hour class and forms part of the Engineering Technology curriculum. The overall goal of the course is to introduce the students to sustainable technologies and to develop a viewpoint or attitude that encourages “Green thinking” not only in their everyday lives but also in their professional lives. The class consists of two components i.e. class room based and a hands-on project based laboratory.
In the class room 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.

4.1 Project

The goal of the project portion of the class is for students to use their previously gained knowledge and skill in a realistic synthesis experience and meet the requirements listed in section 1.2 above.

This paper is being used to describe the project assigned in spring of 2011. It is hoped that this should help others that may be considering a reality-based experience into an educational program. Although most of the students were Engineering Technology majors, the class was open to the general student population of the University. Therefore we had a mix of students including from disciplines of Architectural Design, Sports Management, Accounting, Marketing, Elementary Education, Physics and Astronomy and Construction Management.

Secondary learning objectives set for the project portion of the class included gaining experience in; Project management, Team work, Verbal and written communication, in designing and manufacturing Engineering Technology products and conducting independent research.

4.2 evGrand Prix Project

As in any large project, it is essential to subdivide the tasks into smaller manageable sub tasks. This is extremely important in an educational setting to insure that each student understands what is expected and is held accountable and responsible for a portion of the work. Mr. Palumbo with the help of his EVI colleague, Mr. Jeff Major, divided the project in to subtasks that could be conducted by a single student or a group of 2 to 3 students. These sub tasks or topics are given in table1, and

these reflected the vehicle and team equipment specifications [6] provided by the evGrand Prix. No guidelines or specifications were provided for the 2011 outreach portion of the competition and so the instructional team formulated a list of

Table1: Topics Proposed

Individual technical topics
1. The development, selection and testing of motor?
2. The development, selection and testing of controller?
3. The development and selection of battery exchange system?
4. Selection and performance of battery technology?
5. Battery management system
6. Charging system development and design.
7. Battery testing program
8. The design and development of power transmission system
9. Race chassis and cage conformity to specifications
10. Inventory control of spares and tools
11. Data Acquisition • Remote System control
12. Data analysis
13. On track data management and reporting sequence in real time
14. Computerized testing or vehicle control
outreach focus areas
1. Develop show materials and display for upcoming public shows at mall and at Owens Tech
2. Develop web site for promoting team?
3. Develop lesson covering basics of electric vehicles for elementary or secondary students
4. Present evGrand Prix racing program to potential 2 or 4 year post secondary schools document what already has been done.
5. Plan to coordinate secondary school and vocational school participation and information meeting
6. Establish a “Face book” fan group. The final fan number will be submitted during the student project reports.
7. Develop lesson covering impact of electric vehicles to the environment
8. Develop lesson using ev racer to demonstrate scientific principles to elementary or secondary students.
9. Marketing plan for race team
10. Develop plan maintain cost ledger and budget
11. Business plan for race team success

objectives and requirements for the students to follow. 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. There were 17 students in the class. Figure3 shows the whole team.

Figure3. The 2011 Team, including class, motorsports club, and advisors

In addition to the class, volunteer students of the BGSU motors sports club was responsible for:

- Fund Raising
- Purchasing of Parts
- Marketing Partner Relations
- Logistics
- Assist in Build and Outreach Elements
- Providing Driver and Crew

Table 2 shows the final selection made by the students.

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 evGrand Prix events. These were posted both electronically on ‘Blackboard’ and as paper calendars in the main meeting room.

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

Table2: Topics Selected

Battery testing program
tires
Inventory control of spares and tools
Battery management system
Computer testing and data acquisition systems
Battery box design cell mounting
Selection and performance of battery technology
Controller selection and electrical system schematics and conformity
Motor development
Chassis overall design and project coordination
Battery box mounting and quick clamp to frame
Charging system development and design.
Battery exchange logistics procedures pit stop methodology and modelling
Chassis Mechanical Fabrication and component mountings
Race chassis and cage conformity to specifications
Establish a “Face book” fan group. The final fan number will be submitted during the student project reports
Develop show materials and display for upcoming public shows at mall and at Owens Tech
Develop lesson covering basics of electric vehicles for elementary or secondary students

Similarly students working on the outreach element designed their materials and had some of these made by involving students from the Visual communications program in the college.

At all times the instructional staff stressed to keep sustainability in mind when selecting components or in the design process. So, for example, students minimized joints and used tubing that could be shaped by bending which requires less energy. Tires were selected that met the performance characteristics but also were made using renewable materials and coded to follow their life cycle that could insure their proper recycling and disposal.

EVI personnel and some of the motorsports club members raised funds or seek donations from industry. Consequently the students had the opportunity to work with latest technologies such as Lithium ion batteries and AC motor drive. Figure 2 shows names of some of the sponsors and organizations supporting the team efforts.

Figure4. Some of the sponsors and other organizations involved

Each lab session started with a short meeting, where everyone reported any problems they were encountering. This allowed others to help with suggestions or even resources and kept everyone informed about the overall progress. This way all students learned from one another. The posted milestone sheets were also reviewed thus keeping everyone aware and allowing for planning for the upcoming outreach events. Often students worked outside of the scheduled lab times. It was refreshing to experience the motivation of the students who wanted the team to succeed and worked to solve the problems before them.

Figures 5 to 11 show many of the activities conducted and some of their results. As the semester progressed, each student wrote a technical report covering their own subproject. A week prior to the end of the semester all design related reports were assembled into a technical manual and some students were assigned to

assemble and summarize these into a final overall report. The students completing the outreach activities assembled their reports into an outreach manual. A volunteer team of students were ultimately selected to travel to the final event. Selections for this travel team were made based on students' interest and need, including the presenting of the research results. Several were involved with the logistics of the trip to Indianapolis. 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 setup and presented the outreach exhibit at the speedway and worked as the pit crew.

Figure5. Student working with motor controller

Figure6. A student working with batteries with Mr. Major

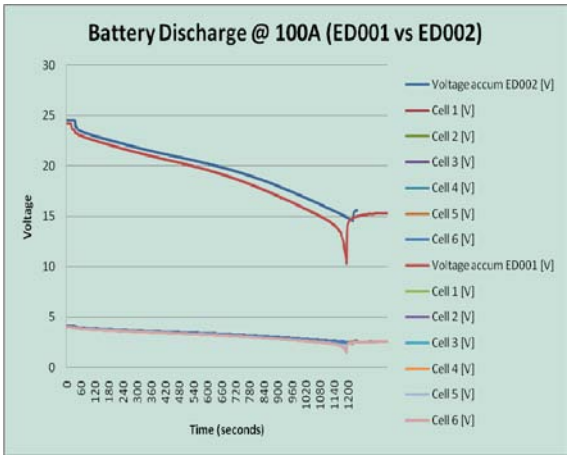

Figure7. Results of the Battery charging –discharging experiment

Figure8. Students working on modifying the motor

Figure9. The Battery exchange system

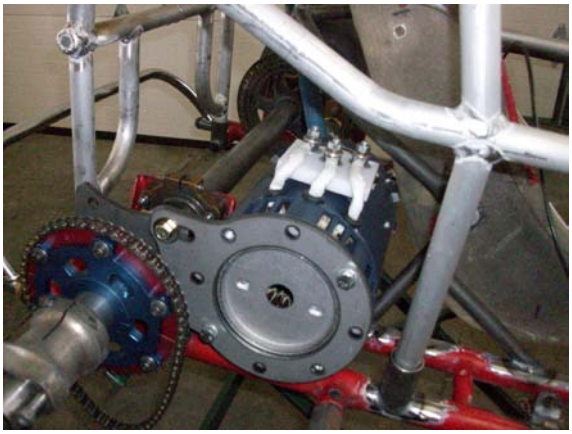

Figure10. Student designed and built motor mounting and drive system

Figure11. After First Test of Racer at Fremont

5 Results

Through the research and development process, the students built a racer with the following 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)

Performance
- Top speed - 50 mph
- 20 miles/battery set
- 156.5 mpg
- One pit stop 7 seconds

Featured student technical innovations included: Battery change out system, Battery management system and 3 phase motor application

5.1 Funding and cost of racer.

Cost to build the first racer amounted to $13,000. A large portion of that 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.

A key point is that the students did the majority of the fundraising for the competition. Cash and in-kind (product) donations totalled $21,000. It must be pointed out that this was new money to the college. No tuition or tax dollars were used to complete the activity.

5.2 Featured Outreach Efforts

Over the semester, the outreach effort reached a documented 10,000 people. 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 last noted effort, 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 14 illustrate some of these activities.

5.3 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 that included two teams from the UK, managed to bring their racers, technical report and outreach documentation to the international competition.

Figure12. Outreach Booth at Owens Community College

Figure13. Radio show at a racing show in Bowling Green as part of outreach.

Figure14. Teaching High school students, as part of outreach.

Figure15. Display at Woodville Mall show as part of outreach

Figure16. BGSU students demonstrating features of racer to Penta Career Centre students.

Figure 17 shows the team at the Indianapolis motor speedway and figure 18 shows the BGSU racer setting up a pass during the race.

The BGSU team was placed well in the on-track and academic elements of the competition as follows:

- 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 8th in race as a result of a late in race mishap with slower racer.
- First Place in Educational Outreach Competition
- Completed 7-second pit stop, fastest in competition.

- Finished 8th in race as a result of a late in race mishap with slower racer.
- First Place in Educational Outreach Competition

Figure17. Crew at the Indianapolis speedway

Figure18. BGSU racer (#9) setting up a pass during race

6. Discussion

The project met all of the original objectives stated in section 1.2 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.

Students often had to interact with vendors of parts and work to meet the specifications provided by the evGrand Prix. They had to design, i.e. 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. In his state of the Union Address in January 2012, President Obama challenged colleges and Universities on lowering costs while preparing students for real jobs. This project clearly meets this challenge by lowering cost through sponsorships and the reality based project.

Students were also exposed to applying sustainability in all their tasks. Hopefully this adds a dimension to their way life and a realization that sustainability is an attitude of minimizing the use of resources within the traditional fields of engineering technology problem solving.

The students experienced success and failure as a direct result of their work. As with any technological problem solving activity, there are many solutions that can meet the goals of the project. In other words there are many right and many wrong answers. The instructional staff had organized and administered the activity to insure individual student accountability. The students that applied themselves and completed their work benefited most. They were tested in the real world and were willing to demonstrate their ability for all to see. They received the feedback they needed to determine where they need to improve and where they can excel. All students experienced the effects their work had on the success and failure of the team as a whole. Students who did not or poorly complete their assignments, or did not apply themselves or contribute were graded

accordingly. By not testing themselves they do not know what they can do or what they need to work on to be a contributor to the society. Hopefully the experience will motivate them to work harder in their next project and when they get into the workplace? More than anything, they experienced that with proper management a group of individuals can achieve more together acting as a team than any group of individuals acting separately.

7. Summary

A national goal is to reduce energy dependence, maintain clean air and create jobs for Americans. To help meet these goals electric propulsion systems are being applied to vehicles in hybrid and plug-in electric configurations. Also there is the problem of reduced funding for Engineering Technology programs in the nation. Literature has shown that the graduates of Engineering Technology often lack the skills of problem solving, working in teams and technical writing.

In this reality-based project, students organized into teams, funded, designed, built and raced a racer powered by electricity. They also developed materials such as posters and brochures and conducted public outreach activities.

The program completed demonstrated how building and racing an electric vehicle can be successfully used to both educate and motivate students and at the same time demonstrate the performance, value and benefits of electric vehicles to the public. Students came away with the idea they can make a difference and a sense of success that they could compete on a level with their peers.

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MG Tires
Enerdel
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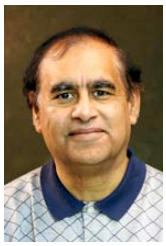

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