Undergraduate Research and Development Explores new Technologies in Energy Conservation Innovations

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Abstract

The Experimental Vehicles Program (EVP) was created in 2004 as an umbrella program for undergraduate experimental vehicle design teams. The EVP in 2013 consist of the Solar Vehicle, Moonbuggy, Baja SAE, Formula SAE, and Solar Boat. The EVP has also recently added the Hybrid Car to its collection of projects. Some of the five projects have the hope of fostering undergraduate student research as well as expanding student knowledge in the fields of green energy and energy conservation.

The Solar Boat project, participated in every year by the EVP, has been one of the most innovative and ground breaking research test beds for new energy efficient technology. Every year students work in teams to design, construct, and test novel vehicle designs for participation in national and international competitions. Due to the competitive nature of each of the competitions, students must use cutting edge technology and design methods in order to create the best entries possible. The Solar Boat must harness renewable energy to propel itself while at the same time excel in both endurance and sprint disciples. This allows the students to delve into new technologies to make their vehicles outshine and out compete their competitors. The developmental ingenuity that is required to make energy efficient vehicles is completely derived from the students and has been a source of numerous innovative advancements. Vehicles such as the Solar Boat and the Hybrid Car allow the students to gain knowledge in a highly contested area such as green energy.

Projects such as the Solar Boat and the Hybrid Car perform a vital function in the professional development of students. The projects provide a forgiving environment in which students can test their classroom knowledge in a real-world setting and learn important skills such as leadership, effective communication, and working as a team member. Furthermore, the students in the EVP develop highly versatile and qualified skill sets that will allow them to fill various positions within the workplace. Graduates that are able to research and produce green energy technologies will have a leg up in their future endeavors both academically and professionally. Additionally, those students that are energized by their undergraduate education experience have an enhanced possibility of retaining the information they acquire and aspire to advance degrees or academic engineering research [1].

Introduction

An engineer's ability to get the most "work" out of the least amount of "energy" has become the cornerstone of the energy efficiency movement over the past several years. Competent, innovative engineers are needed now more than ever to help solve some of the most complicated problems in the advancement of conservation. The various projects of the Middle Tennessee

State University (MTSU) Experimental Vehicles Program (EVP) allow engineering technology students to apply their groundbreaking ideas and classroom knowledge to real-world problems such as energy conservation. Projects such as the Solar Boat and the newly added Formula Hybrid Car supply a creative environment to nurture and inspire innovative thinking [2].

The Solar Boat project has been a rolling test bed of groundbreaking innovations since it was brought into the EVP. Each year the new team comes up with better and more efficient ways to convert power into energy. The current Solar Boat team using extensive research and resources from past teams has altered several specific aspects of the vehicle to make the boat more energy friendly. Additionally, in order to broaden the available research for energy conversion the EVP took on the Formula Hybrid Car project. The students hope to design a vehicle based on the previous Formula project and revamp the engine.

Annually, peer-led teams work diligently to design and manufacture energy efficient vehicles. These unique research projects provide great benefits for the professional development of engineering and engineering technology students. Hands-on learning and in-depth research in areas with such social impact as energy conservation put the students ahead when entering the work force. In addition, these particular projects help students learn to think inventively, communicate professionally, manage projects efficiently, and work in a team environment [3]. These projects also provide invaluable experiences which give EVP students a competitive edge upon graduation. The innovative projects have increased interest in engineering, incorporated classroom learning into hands-on experiences, and fostered an atmosphere of peer-led team learning which has benefited the students both personally and academically.

The MTSU program differs from other undergraduate research programs because it provides hands-on experience with tangible results. The goal of the EVP is to encourage students to engage in research centered on the course of study they are particularly interested in. As a result the undergraduates are able to delve deeply into that course of study. During the creation of the individual vehicles the students have the opportunity to work and create with each other as well as the machinery that in available on the Middle Tennessee State University campus. Approximately 80% of the vehicle parts are manufactured in MTSU machine shops. Additionally, the hard work that the students put in to the vehicles and their engineering topics comes to fruition during the competitions. The students have the opportunity to nationally and internationally display their work to the public and gain recognition for their hard work. Aside from the competition aspect the students are able to use the work they put into the EVP vehicles as a senior project or senior thesis. They can sign up for a course and the research that is put into creating their experimental vehicle can then be made into a portfolio and turned in as a grade. This supplemental grade system is a useful recruiting tool but it also allows the students to spend a sufficient amount of time working on the vehicles and perfecting the vehicles for the competition stage.

Energy Conservation through Innovation

Often, these projects serve as rolling test beds for the latest innovations in various technical fields and are accompanied by a great deal of student research. The students themselves are responsible for the innovative ideas displayed in each vehicle. The student's research and test out their ideas to make sure plans will be beneficial to the overall performance and energy conservation of the vehicle. One of the most valuable tools the students use for research is a computer program known as Autodesk Inventor. Inventor allows that students to test their innovative ideas in computer form before taking the time to actually manually create the parts. The students can simply put their design plan into the program and the simulation will inform them the approximate weight, whether or not it would actually be functional with in the vehicle, and how the design could with stand up to particular elemental conditions such as gravity or mountains. The Inventor program is an invaluable tool to the EVP students saving them time, money, and resources. It also allows the students to learn how best to formulate their vehicles through the process of trial and error. Also available are the valuable resources in the MTSU Engineering Technology Complex. Numerous engineering machines are at the ready for the students to utilize when they need to fabricate or modify a part to enhance the design of their vehicle. Another major factor that affects the scheme of each year's vehicle is the performance of the previous model. The current teams have the benefit of learning and improving upon old designs. Collaboration, research and ingenuity help the students achieve award winning designs.

Solar Boat

MTSU offers several nationally competitive experimental vehicle projects as extracurricular activities for undergraduate students [4], including a Solar Boat project. The Solar Boat project was founded following the inception of the Institute of Electrical and Electronics Engineers Power Electronics Society's Solar Splash Competition, an international collegiate competition showcasing solar/electric boating [5]. The overarching theme of the Solar Boat project is to encourage students to excel in their studies and to get them excited about researching energy efficiency. The project provides fundamental knowledge and hands-on experience valued by employers and serves to fill in and gaps in understanding from the students' classroom education. The solar boat project focuses on the capture, utilization, and storage of solar energy to power a special-purpose boat. The boat design must follow a set of regulations to accomplish numerous pre-determined outcomes. The boat must be able to perform and excel in competitions such as the Solar Slalom, sprints, and endurance [6]. These harsh stipulation, nevertheless, leave each team room to explore new and innovative ways to create a more efficient vehicle for the competition. The Solar Splash Competition may be classified as a "brain sport," an activity giving students an opportunity to experience real-world design and engineering problems such as energy conservation [7]. In 2013, the MTSU Solar Boat team was extremely successful in the Solar Splash competition winning 7th Place Overall, 2nd place in Sprint, the Design Achievement Award, the Outstanding Workmanship Award, and 2013 Participation Award. The 2013 team is pictured in Figure 1. In 2010, the team placed 8th overall and brought home the Sportsmanship Award. The new Solar Boat team is able to use the resources and knowledge of competition experienced vehicle to build their new designs.

The EVP Solar Boat team members collaborate on all decisions throughout the lifetime of their project. Together the students decide how they want to build their boat, conduct all the necessary research, construction, and testing in preparation for the annual competition. During the Solar Boat project students are faced with challenging dilemmas that are best solved through creative problem solving.

Figure 1. Innovative Drive Train

The 2013 award winning Solar Boat consisted of several ingenious methods of making the vehicle most efficient. For example, the 2013 Solar Boat incorporated an innovative drivetrain system, pictured above that provided an adjustable trim while simultaneously facilitating rudderless steering.

Figure 2. 2013 Solar Boat Team

The 2013 design also integrated a fully functional dash that provided the pilot with all the need to know information about the Boat's support systems. The current, 2014, team has taken these creative ideas added their own to establish a new and better design. The new Solar Boat team using extensive research and resources from past vehicle designs has altered the vehicle to make it more efficient. Their first modification is to alter the propeller. This will help to reduce cavitation in the water. Cavitation is a result of rapid movements of objects in water; too much cavitation can be inefficient. The adjusted propeller helps to stabilize forward motion. This simple modification, designed by Torqeedo, will eliminate vortex which was a problem with the previous propeller.

Figure 3. 2013 Solar Boat during Sprint competition

Changes to the driveshaft will allow the propeller to operate more efficiently. The current driveshaft needs to be lengthened in order for the propeller to be in certain positions at a given speed. If the length is doubled, from 12 inches to 24 inches, the boat will be able to have a smaller angle to get the propeller into position and the thrust will not be wasted. Therefore, with a longer driveshaft, the boat will operate more efficiently due to the propeller operating competently and the thrust will be applied more resourcefully on the back of the boat. In addition the lengthened driveshaft coupled with the improved propeller may allow the team to change from a two-motor to a one-motor configuration. This modification would allow the Solar Boat to lose weight and excel in the sprint competition. The picture to the right is the 2013 Solar Boat during the sprint competition. This change, however, still needs extensive research to determine if this is the most energy efficient course.

If the one-motor configuration turns beneficial the team has already devised a scheme to balance the loss of power to the engine. The team will supplement a smaller motor that uses less energy and will solely be used for the endurance competition. This smaller motor will also allow the solar battery system to last longer. Batteries used in previous Solar Boats have ordinary car batteries which give plenty of amps but only for a short period of time. The new team has discovered smaller 12 volt and 12 amp batteries that weigh less than 7lbs. The team will be able to use multiple batteries taking most of the pressure off the motors during the endurance competition.

Formula Hybrid Car

This year the Experimental Vehicles Program has added an additional project to its already versatile array of opportunities. The Hybrid Car project is to be loosely based off a Formula One design using alternative fuels and battery power. The rules stipulate that students must be responsible for the concept, design, and fabrication of a Formula Hybrid vehicle. The vehicle must additionally be an open-wheeled design with a single seat. The Formula Hybrid competition adds another layer of complexity to the challenge by forcing the students to conform to a design that emphasizes drive train innovation as well as fuel efficiency in a high-performance application [8]. Figure 4 is an example of what the Formula Hybrid Car will look like.

Figure 4.   Formula Hybrid Car Example

The Formula Hybrid Car is a bit of a departure from the previous projects the EVP has become involved in over the years. This vehicle requires the student to think outside the box to incorporate energy efficient designs into a high-powered, high energy vehicle. This year's students have devised a plan to combine the use of batteries and motor power to supplement the energy used while still providing the same expedient force needed for the competition. Their plan is to formulate a design that uses mostly electric power but also utilizes a small combustion engine. The team estimates that with their innovative design the Formula Hybrid Car would only use a third of the fuel consumed by regular vehicle. In the future the team hopes to transition from a fuel and electric powered model to an entirely electric version.

Student Benefit

Projects such as the Solar Boat and the Formula Hybrid Car provide a multitude of benefits. Annually, approximately 20 students work on each project helping to provide input from several different academic and cultural backgrounds. Students typically participate in the EVP as an extracurricular activity but others choose to pursue the vehicles as a senior project, and are graded by their team leadership. The students once split into their team work diligently to design and create the most efficient and competitive concept for their respective vehicle. For example, the Solar Boat team must consider how the aquatic vehicle will operate most effectively in a sprint competition as well as an endurance competition. Additionally, the students must consider what the best way is to power the Boat to suit both situations. Complex issues such as these cause the student to enlist their critical thinking skills. They turn to in-depth research and collaboration to find applicable solutions.

Additionally, the students gain confidence through taking their completed vehicles to competition. The prestige of competing alongside highly acclaimed participants reassures the students of their excellent work. Furthermore, the students are validated during the competition when their impeccable designs receive awards and accolades. Figure 5 shows the 2013 team proudly displaying its five awards. The students also get the opportunity to show off their work but displaying it on campus and participating in summer camps to get future aspiring engineers interested in EVP.

Figure 5. 2013 team with awards

Throughout the process the students are able to build upon the building blocks of knowledge they acquired in the classroom. They become more well-rounded and confident in their own ideas and abilities. These projects allow the students to bring their own ideas to the table and use the tools provided to explore them and fine tune them. This type of critical thinking and selfassured behavior puts the students involved in the EVP leaps and bounds ahead of their peers when entering the job market.

Conclusion

The EVP projects provide a change in the traditional course structure from lecture, word problems, and exams while offering a great opportunity for inquiry and discovery. The inclusion of hands-on research projects in the freshman level has created interest, enthusiasm, and self-motivation for science, technology, engineering, and mathematics (STEM) students. While the research projects require more time than traditional lecture course, the students walk away with a greater understanding of the material and a real-world experience of their chosen field of study. The on campus engineering laboratories help to facilitate the complete working experience for the students. The labs allow the students to design, create, and enhance their vehicles. Each student has the ability to work on every aspect of the vehicle they are creating and hone their skills. The machine shop allows the students to test their designs as well as gain invaluable experience working on machines such as laser cutters that they will be using during their future careers. These projects help students to sharpen their skills for future workmanship, such as team work, understanding responsibility, and making use of techniques learned in class. Moreover the EVP students gain an irreplaceable experience and lifelong relationships while working with international students and partners. As the students learn to cooperate together to solve current social economic issues they begin to understand the importance of collaborative research in complex problem solving. The students also get to reap the benefits of their hard work with prestigious awards won each year by each vehicle and participating students. This distinguished research program will continue to provide an undergraduate learning experience with the latest advancements in technology and energy conservation. These versatile undergraduates have the ability to take the vehicles from previous years and find their failing. They then use their engineering talents and research savvy to improve upon those mistakes making the vehicles as energy efficient as possible.

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