An Enhanced Educational Experience for Capstone Design Projects: Using SAE Student Groups in An Industry Sponsor Role

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Abstract

The Mechanical Engineering Department at Saginaw Valley State University (SVSU) is enhancing the educational experience of students by using Society of Automotive Engineers (SAE) student groups in the role of industry sponsor for capstone design projects. In many engineering programs, industry sponsors are used as a resource for capstone design projects. This format involves many institutional and educational benefits and challenges. Industry sponsors provide capstone design students with a project that includes a problem definition, domain knowledge, possible funding, and possible facilities. Capstone students work in a team on the project, experiencing the technical, teamwork, leadership, political, and emotional aspects of the design process. The institution provides advanced technical and, sometimes, entrepreneurial outreach to the region. Using SAE student groups in an industry sponsor role enhances the education experience in many ways. The SAE student group gains the experience of managing an engineering project by providing the problem definition, prioritizing groups, choosing the projects to outsource, establishing budgets, setting deadlines, allocating resources, and supplying the domain knowledge. Capstone students involved in these projects experience all the highs and lows of these challenges. The SAE student group sees the benefits from a form of outreach. Using SAE student groups in the industry sponsor role exposes SVSU engineering students to a broader design process experience, thus enhancing their education.

Introduction

Saginaw Valley State University (SVSU) is a regional comprehensive public university with a current level of enrollment of approximately 9000 students. The university is located in a heavily industrialized area of east-central Michigan in which over 2200 manufacturing firms, ranging from small operations to Fortune 500 companies such as The Dow Chemical Company and Delphi Saginaw Steering Systems, are based. The ABET accredited mechanical engineering undergraduate program resides within the College of Science, Engineering and Technology. The SVSU mechanical engineering capstone design experience has some projects sponsored externally by regional industry and some projects sponsored internally. In 1998, a group of SVSU students participated in Society of Automotive Engineers (SAE) Formula SAE (FSAE) competition. This small dedicated group of students had limited success finishing 89th out of 95 schools. In an attempt to increase student participation and placement in this outstanding collegiate design

competition the SVSU FSAE student group was introduced as an industry sponsor in the mechanical engineering capstone design courses. Many universities use a whole SAE project as a capstone design project option to students[1]. SVSU mechanical engineering has the SAE student group offer specific sub system projects to capstone design students as a project option.

SVSU Mechanical Engineering Capstone Design Course

The SVSU mechanical engineering capstone design course has four participants; the student design teams, the industry sponsor or customer, the design team advisor, and the course instructor. The student design teams' responsibilities include interacting with the advisor and customer, attending weekly lectures, and developing a set of deliverables that includes a planning chart, three reports, four presentations, a notebook, and a prototype. The customers' responsibilities include providing initial project objectives, interacting with student design teams, hosting visits to a facility, attending presentations, and providing funding. The advisors' responsibilities include meeting weekly with design teams, providing direction, monitoring progress, encouraging use of university resources, and grading reports and presentations. The instructors' responsibilities include soliciting projects, lecturing on the mechanical design process, organizing student design teams, assigning projects, appointing advisors, reviewing budgets, organizing final presentation facilities, and assigning the final grades.

The students' grades are based on the set of deliverables, peer evaluations, a professional evaluation by the advisor, and a lecture exam. The majority of the student's grade is based on three deliverables: the final report, the final oral presentation, and the final poster presentation. These presentations are held at an annual design conference at the end of the term. The public is welcome to this conference and asked to participate via jury evaluations. The customers and advisors must attend this event and provide feedback.

The format of the SVSU mechanical engineering capstone design course is not unique. The SVSU capstone course is an industry sponsored capstone design course that is becoming the standard in engineering education[2]. What is unique is using SAE student groups in the industry sponsor role. These capstone courses typically provide many benefits and challenges for the sponsors and the university. The benefits and challenges are shared with the SAE student groups when the SAE student groups are the industry sponsors. The benefits and challenges are on both an institutional level and an educational level.

Institutional Benefits & Challenges

There are many institutional benefits of capstone design courses for both the university and the local industry. The university has increased visibility and improved reputation with local industry. Cost effective services are provided to local industry. Professional networks between local industry, faculty, and students are established. Graduates are better prepared for industry employment. There are more recruitment opportunities. In rare cases, intellectual property is created resulting in new jobs and businesses. The SVSU SAE student groups realized these benefits from both the university side and the industry side.

The SAE group's visibility and reputation improved with administration, faculty, and other students. University annual financial support more then tripled from $4130 to $12,500 in three

years. Shop facilities received university support for an update and seven new machine tools were purchased. Faculty supported smaller "mini" SAE related design projects in their classes. The SAE group's membership almost tripled from 7 to 20 in three years. The visibility of the SAE vehicles improved the reputation of SVSU's engineering program at auto shows, professional society meetings, and open houses. The SVSU FSAE group improved its overall placement in the FSAE competition from 89th out of 95 to 51st out of 120 in three years. The most dramatic improvement was in the design event, where SVSU FSAE improved from 65th to 15th in three years.

The cost effective services of the capstone design groups helped increase the SAE group's instrument holdings with a slight increase in SAE group's budget. Specifically, engine and chassis dynamometer facilities, instrumentation, and hardware were designed, built, and tested. The capstone design groups act as the research arm of the SAE group at very little cost of time and money.

The professional network between the SAE group and regional industry is shared with the capstone design students and advising faculty. This network results in opportunities for other possible student and faculty projects. Further recruitment and employment opportunities for students are available via this network. Currently the SAE groups at SVSU have networked with over 70 corporations, machine shops, job shops, retailers, foundations, professional societies, individuals, high schools, and career centers.

Intellectual property currently has yet to be developed as a result of "SAE group = industry sponsor" experience. However, several unique and useful prototypes have been designed, built, and tested (See Table 1). All prototypes are still in use today by the SVSU SAE groups. Some are actual parts of the racecars, others are testing equipment and processes for future racecars, and still others are helpful devices for use in the paddock area.

Table 1: Several Unique And Useful Prototypes Resulting From FSAE Industry Sponsor Role

Prototype	Discussion
• Racecar Tubular Space Frame	Triangulated steel tubular space frame benchmark at SVSU. FSAE judges "Best steel space frame at 2001 FSAE Competition"
• Racecar Mechanical Butterfly Shifter	Integrated shift and clutching via cables
• Racecar Steering System	Custom rack and pinion steering system
• Chassis Dynamometer	A vital resource built for rollers saved from scrap.
• Racecar Steel Metal Front Upright	Sheet metal uprights benchmark at SVSU via a complete analytical and physical validation
• Engine Dynamometer Laboratory Set Up	Remote load, cooling, video controllers plus up-to-code ventilation, fuel, data cable plumbing
• Engine Dynamometer Test Stand With Pitch and Roll Tilting Capabilities	Compact portable stand to test different engine packaging configurations and simulate lateral g's
• Engine Dynamometer Cooling Tower	Permanent tower eliminates need for radiator
• Paddock and Display Lifts	Front and rear lifts operated by cordless drills
• Design of Experiment (DOE) Process of Testing, Tuning, Setting up, and Designing a FSAE Racecar	Experimental process to efficiently and effectively test, tune, and set up a FSAE racecar resulting in improved future designs and resource allocation

The institutional level benefits experienced by the SVSU SAE group as a result of being an industry sponsor to the capstone design course have been enlightening. The SAE group realized the advantages and realized the extra management task. The SAE group extended their weekly meeting time from 1 hour to 2 hours. The meeting format matured from informal gatherings to formal design reviews requiring each subsystem group to present with either overhead transparencies or a data projector. A new project manager position was created within the SAE group to coordinate the many subsystem projects. The SAE group arranged to have a phone line in their workspace to stay better connected with their subsystem design teams. The maturation of the SAE student group to perform the extra management task enhanced the current SAE group's education and created a foundation on which future groups can build.

Institutional challenges of capstone design courses include finding industry-sponsored projects of the right scope and allocating resources, time, and people to the projects. These challenges were put to the SAE group. Initially, the SAE group struggled with this format. Currently, the SAE group independently prioritizes the projects and identifies the capstone design group for each project. The SAE group establishes a budget for each of the projects. The SAE group defines an initial set of measurable objectives to define the problem for each capstone group. The SAE group provides each capstone group with a list of resources for each of the projects. The SAE group assigns a SAE group member as a liaison to each capstone group. These real world teaming, delegating, prioritizing, and managing challenges provide invaluable experiences to engineers.

Educational Benefits & Challenges

Educational benefits and challenges include all the technical, teamwork, leadership, political, social, ethical, and emotional aspects experienced within advanced level, real world, open-ended engineering design projects. SVSU attempts to include all of these aspects that should be included in an ABET accredited capstone design course[2]. Inherently capstone design projects challenge the students in the above ways. The overall learning that takes place over the entire design process is the student's educational benefit.

Both the SAE student groups and the capstone design student groups share the highs and lows of the capstone design educational experience. In the design process the time between thrill and panic is sometimes very short. The initial problem definition stage of the design process is the most important. Panic needs to be experienced early instead of late. Advising and customer interaction early in the process gives the capstone design students an early reality check. Using an SAE group as an industry sponsor helps because they are on campus and generally easier to contact early in the design process.

Complexities

There are three identified complexities in using an SAE student group as an industry sponsor of capstone design projects.

First, the SAE students are tentative when being too critical of capstone students. Being too critical is a common problem with industry sponsors. The sponsors do not want to be the cause of a student's failure. This tentativeness is eventually resolved with experience in dealing with these types of projects. The capstone course is a real world experience and criticism is valuable real

world feedback vital to the success of the project. Maturity in giving, handling, and utilizing criticism is a valuable skill.

Second, students have a hard time accepting other students as experts. This experience is a first for some and egos are fragile. Weekly design meetings help to resolve this problem when the capstone students realize the SAE students are there to help and intimately know the problem. Swallowing your pride and knowing when to listen are other valuable lessons. Experts are all ages, both genders, and different races and much can be learned from them.

Third, there is a guaranteed cross over between the SAE group leadership and the capstone design group resulting in a "customer/supplier" conflict of interest. Students in this situation are encouraged to seek out as much feedback as possible from the body of the SAE group and/or a third party. SVSU's third party is a local engineer who makes his living in the racing industry and is kind enough to donate his time to provide feedback. Using an SAE student group as an industry sponsor of capstone design projects has complexities but these complexities provide valuable real world experiences that enhance the student's education.

Conclusions

The Department of Mechanical Engineering at SVSU is using SAE student groups in the industry sponsor role exposing the students to both institutional and educational level benefits and challenges the students did not have before. The benefits and challenges have improved the SVSU FSAE group and enhanced the education of the SVSU students. There are complexities with this arrangement but the complexities provide valuable real world lessons to students. At the very least the SVSU Mechanical Engineering capstone design course is a typical ABET accredited industry sponsored capstone design course. Using an SAE student group as an industry sponsor of capstone design projects provides a unique experience for SVSU students enhancing their education.

Bibliography

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Biographical Sketch

Brooks P. Byam is an Assistant Professor of Mechanical Engineering at Saginaw Valley State University appointed in 1998. Dr. Byam received a B.S. in Physics from Alma College in Alma Michigan in 1991, a M.S. in Aeronautics from The George Washington University's Joint Institute for Advancement of Flight Sciences at NASA Langley Research Center in 1993, and a Ph.D. in Mechanical Engineering from Michigan State University in 1999. He teaches statics, mechanics of materials, vibrations, controls, ground vehicle dynamics, machine design, and senior capstone

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