Capstone Design CONFERENCE 2024
JUNE 3–5, 2024 ▶ KNOXVILLE, TENNESSEE

Impact of Requesting Funds from Industry Sponsors to Support Capstone Projects

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As part of graduation requirements, the School of Engineering and Computer Science at Washington State University – Vancouver (WSU-V) requires a two-semester course in capstone design experience. The main objective of this course is to allow students the opportunity to undertake and complete an open-ended design project. Team-based capstone design courses provide opportunities for students, not only to apply their classroom-based knowledge and skills learned in the course work, but also to develop project management, teamwork, scheduling, and communication skills in the form of both oral, written, and other formats. This paper discusses the strategies taken by the School of Engineering and Computer Science at Washington State University – Vancouver (WSU-V), to attract funding from the local industries to support their senior capstone design project(s). Since the engineering programs were established at WSU-V, in early 2000, our engineering students have been working on their capstone design project(s) sponsored by the local industries without any fees. However, most universities in the region have been charging some fees for the industry project(s) for many years. Starting the 2022-2023 academic year, we initiated the request for reasonably low fees in support of their proposed capstone projects. The procedure and the outcomes are presented in this discussion.

Keywords: capstone design project, project sponsorship, industry-sponsored funding, multidisciplinary project

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Introduction

By its very nature, engineering involves design - creating solutions to real-world problems. While the design process can occur based on existing technologies and well-established science, engineering innovation often requires a connection to cutting-edge science. Engineering design, however, is a combination of theory, learned from textbooks, and practice learned from experience in research and/or industry laboratories.

The integration of capstone senior design project courses into undergraduate engineering education has been found to enhance student performance and improve retention rates[1]. It also prepares graduating engineers to work in rapidly changing environments defined by a competitive global marketplace. Industry is asking for engineers with better communication and teamwork skills, and most importantly, a broader understanding of how to solve real-world problems and create value in the marketplace. Furthermore, students working on an industry-sponsored capstone project would explore employment opportunities with the capstone design project sponsor company.

As part of graduation requirements, the School of Engineering and Computer Science at Washington State University–Vancouver (WSU-V) requires a two-semester course in capstone design experience. The main objective of this course is to allow students the opportunity to undertake and complete an open-ended design project. Industry project sponsors and department faculty perform supervision of these projects.

The course is a practice-oriented design class in which students integrate and implement their engineering knowledge and skills in all three disciplines, electrical, mechanical, and computer science to solve a real-world design problem. Special emphasis is placed on integrating constructability concepts with electrical systems, mechanical systems, and computer software. Student groups not only complete project designs, but also perform feasibility studies, value engineering, and prepare a construction schedule and cost estimate based on the designs they have generated.

Educational Objectives of Capstone Design Projects

Capstone design courses play an important role in the preparation of engineering students for their professional practice and future career success. They allow students to apply what they have learned before their senior year along with newly developed skills relating to solving real-world design problems, often in a team environment with external clients, namely project sponsors.

Team-based capstone design courses provide opportunities for students, not only to apply their classroom-based knowledge and skills learned in the course work, but also to develop project management, teamwork, scheduling, and communication skills in the form of both oral, written, and other formats.

In the United States, accredited engineering programs are required to offer a major design experience; most programs fulfill this requirement through a capstone design course. Differences in course learning outcomes, management, structure, duration, projects, student teams, and required deliverables exist among institutions. Successful strategies in engineering capstone design education are a vital part of any ABET-accredited engineering program.

Capstone design projects have become commonplace among engineering and engineering technology programs. These projects are valuable tools when assessing students, as they require students to work in teams, communicate effectively, and demonstrate technical competency. The use of industrial sponsors enhances these projects by giving these projects more of a "real world" feel[2].

Students, industry sponsors, and universities are offering more and more opportunities for students to work on industrially sponsored projects for credit[4-8]. While some may question the need for a university to be involved in this relationship, arguing instead for co-ops or internships, this paper quantifies the importance of a course or program as a mediator of this relationship.

Participation in capstone design deepens a student's understanding and promotes the communication and teamwork needed to solve complex problems. Also, enabling students to be part of the intellectual process instills in them a sense of fulfillment and imparts life-long benefits. Capstone design courses are also one of the most effective ways for engineering departments to facilitate the outcomes of ABET criteria 3a-k[3].

One way to prepare future engineering professionals to interact with industry researchers and designers and push the frontiers of engineering innovation is to introduce this connection to engineering students.

The Computer Science, Electrical Engineering, and Mechanical Engineering programs at Washington State University-Vancouver (WSU-V) have Senior Capstone Design Project courses that are two-semester course sequences in which students learn, synthesize, and develop the skills of engineering practice with skills learned in their previous coursework applied to real-world engineering projects usually sponsored by local industries.

Before taking the senior capstone courses, students learn the engineering design processes and the tools that encourage successful innovation in their junior year.

Projects are assigned to teams of three to five students, depending on the scope of the project. Most teams comprise students from the same major – computer science, electrical engineering, or mechanical engineering, but some are interdisciplinary, mixing students from different majors. The teams work in concert with the sponsor and the course professor who coaches the team and monitors the project progress throughout the year.

The projects can include conceptualization, analysis, and simulation, and often include prototyping, and validation of the engineering solutions. Projects can be the design of products, parts, systems, or sometimes the simulation of an existing system to further improve or optimize its performance. Some capstone design projects could be redesigning an existing system subject to repeated failure during the operations.

Typical outcomes and results of these projects include written reports that document the design exploration, refinement and analysis, and prototyping process. Results also include an oral presentation given by the team to their peers in the class, project sponsor(s), and faculty. Documentation of the results is evaluated by both the project sponsor(s) and the faculty in charge of the capstone courses.

Local industries sponsored the most senior capstone design projects. However, some student teams work on internal projects sponsored by the faculty. Not only are corporate project sponsors able to benefit from implementing recommendations but typically retain sponsors for future projects that tend to increase in technical caliber, learning opportunity, and business impact with each successive project sponsorship[7].

Each industry-sponsored project is led by a mentor, the key corporate engineering contact leading the project. Mentors schedule regular check-in meetings to provide guidance and feedback to their student team(s). The mentor also provides feedback to the faculty instructor on individual and team performance. Mentors ensure that student teams have all required materials promptly, including all background documents, drawings, schematics, potential software access, etc.

The faculty project adviser is responsible for managing all student tasks and assignments and monitoring their progress according to the schedule the team has put together.

As defined by ABET, the Accrediting Organization for Engineering Programs in the United States, engineering design is a process of devising a system, component, or

process to meet desired needs and specifications within certain design constraints[2]. It is an iterative process that involves identifying the problem at hand, developing requirements, completing the design problem statement, performing analysis, generating alternative and feasible solutions, evaluating those alternatives against the requirements, considering risks, and making trade-offs - all to obtain the most feasible and practical solution under the given circumstances.

ABET Requirements for Capstone Design Projects

All students in an ABET-accredited engineering program in the US must complete a culminating design experience. Providing a mechanism to connect students' design education to the research conducted in laboratories will create a bridge between the discovery of research and the translational potential of design.

Projects that challenge students to design a technology, device, or system to complement or augment the methods or aims of a research and development project. Eligible projects are expected to meet the following requirements:

- Students, as a team, must conduct projects.
- The solution to the challenge should not be pre-determined (i.e. the students are not simply implementing a design developed by the PI), so that the students go through the complete engineering design process - including development of a prototype or system simulation, as appropriate.
- The project should require students to consider relevant standards and realistic constraints.

The faculty capstone advisor functions as an intermediary on items like documentation, labs, and reports. This minimizes the amount of time that a sponsor is required to spend reviewing draft-level documentation. Occasionally students require a little extra motivation from the faculty advisor as well!

For the projects involving prototyping of the final design, either a full-scale or a scaled-down model, our students were able to use the sponsor company's facilities and the mechanical and electrical labs on the WSU-V.

Since our mechanical and electrical engineering undergraduate degrees were established at WSU-V, our School of Engineering established relationships with local industries to sponsor capstone projects. The school's experience with industry-sponsored capstone projects gives us a good understanding of what students can and can't be expected to accomplish during their senior year.

Supplemental Funding Opportunity from the Project Sponsors

Funding is necessary to enable student teams to pursue the design process, from need finding to industry and customer discovery, through prototyping and validation.

When the capstone courses were first established, industry sponsors provided materials and facilities to the student teams but were not asked to provide any direct financial support. In 2022 the School of Engineering proposed to charge the industries sponsoring the projects fees, which most engineering schools have been practicing for many years. The idea was to support the projects and give some revenue to the school. The fees were $2,000 per project with discounts for sponsoring more than one project.

The fees were paid to the University Foundation, making them tax-deductible. Non-profit organizations and government entities could request the fees to be waived. The school's administration was responsible for collecting the fees, not the faculty. This fee schedule is within reasonable limits and comparable, if not less than, with the fees of other engineering schools in our region.

When this was proposed to the industries, some were hesitant. The notion was that we have had projects sponsored for years without having to pay for them, so why now? The school informed the sponsors about the fees in the fall of 2022, saying that the fees were optional for the 2022-23 academic year, but would be required for the 2023-24 academic year. A few sponsors volunteered to pay the fees in 2022 but could not because the school had not yet defined the payment process.

Table 1 summarizes the results of imposing the fees. It lists the number of projects in each of the three majors, before and after the fees were imposed, sponsored by industry, the number of projects sponsored by WSU faculty, the number of industry sponsors that paid the requested fees, the number of industry sponsors for whom the fees were waived, and the number of sponsors that withdrew from sponsorship because of the fees.

When sponsors further considered the fees, they realized that this is a normal practice in most engineering schools, and the fund helps students to develop a much stronger outcome for the project, most welcomed the idea. However, a few requested and received fee waivers. A few others completely withdrew from capstone sponsorship.

We conclude that by starting to charge a fee, most sponsoring industries will appreciate that not only are they going to be more involved in every aspect of their proposed project(s), but also helping our school to make sure that the deliverable outcomes are targeted more specifically toward the goals and expectations set by the sponsors. Also, it is worth noting that our fees are substantially lower when it is compared with what most universities across the nation charge[9].

Table 1: Sponsor Response to the Imposition of Capstone Fees in 2023-24

Number of Sponsors by Outcome	2022-23 (Fee Optional)			2023-24 (Fee Mandatory)		
	CS	EE	ME	CS	EE	ME
Paid Fee	0	0	0	5	5	4
Fee Waived	5	5	4	2	2	2
Withdrew Because of Fee	0	0	0	0	2	0
Sponsored by Faculty	4	1	4	3	0	4
Total Sponsored Projects	11	6	8	11	7	10

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