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Sponsoring student design projects can free up companies' resources, but challenges remain.

Medical device companies often lack the engineering staff for new product development projects. One way to solve this problem is to sponsor a senior design project at an accredited undergraduate engineering program. This option provides the sponsoring company with a team of engineering students dedicated to the project for up to two semesters, depending on the school. Students benefit from the opportunity to work on real-world problems. They gain exposure to project management and product development processes, as well as familiarity with economic, legal, and regulatory design constraints.

How Senior Design Courses Work

Capstone design courses around the country differ in the duration of the course, required deliverables, engineering disciplines, number of credit hours, and level of industry involvement. A description of the capstone design course taught by the author at Marquette University is presented here as an example.

The two-semester design course at Marquette University includes biomedical, electrical, computer, and mechanical engineering students. Students meet with faculty twice a week as well as separately to discuss discipline-specific topics such as FDA requirements, packaging and sterilization, and standards.

Marquette students Ethan Pedretti (left) and Brian Korves work on a prototype of a second-generation assistive feeding device. Learn more about working with academia to help innovate at MDM Chicago, September 11, 2013.

During a typical semester there are 12 projects that involve medical devices. Project teams consisting of three to five students from a mix of engineering disciplines are formed based on the required expertise and skills. Typically, medical device companies sponsor three or four of these projects. The remaining projects involving medical devices are proposed by students, faculty, or external stakeholders on behalf of clients with disabilities.

The course schedule and required team deliverables are based on the design control requirements of ISO 9001 and 13485 and reflect the design process used in industry. During the fall semester, students working on industry-sponsored projects meet with sponsors as early as possible to define the project. Students and sponsors discuss how the problem is currently solved (prior art and other competitive solutions), why a new approach is needed, and how a new product should perform better than what exists (e.g., lower cost, improved performance, or easier to use). As appropriate, teams are encouraged to investigate who might benefit from a new design and estimate potential market size. These activities result in a written project definition. Teams then work with sponsors (and potential customers, if appropriate) to define customer needs and performance requirements to generate the customer needs/target product specifications document. Next, teams generate potential design concepts and determine the best concept, resulting in the generated/final concepts document. At the end of the fall semester, teams submit a written formal proposal describing the design they plan to pursue. Teams are required to justify technical feasibility through appropriate mathematical modeling methods (free-body diagrams, heat transfer calculations, finite element analysis, etc.).

Industry/Student Medical Design Projects

Get the scoop on three real-life collaborations between Marquette University students and Medtronic, 3M, and GE Healthcare.

During the spring semester, teams create a detailed project schedule and risk analysis document. This includes risk mitigation plans to minimize threats to project schedules. Schedules and risk status are updated periodically. Teams fine-tune their design concepts, and construct and test functional prototypes. Informal design reviews occur during meetings with the team, faculty advisors, and sponsors. Designs are revised, and prototypes modified and retested until the design is finalized. The experimental verification document describes testing of the prototype to prove that it performs per the required performance specifications. The prototype is shown to the sponsor for final approval and design validation. A final report documenting the project, including all design inputs, outputs, and verification and validation results, is presented to the class (if not prevented by a nondisclosure agreement). Throughout both semesters, teams compile project notebooks that contain original designs, test procedures and results, meeting minutes, and other project-management-related items. These serve as design history files for the projects. At the end of the course, prototypes, project notebooks, and final reports are transferred to the industry sponsors.

How Industry is Involved

The most common form of industry involvement in capstone design courses is through sponsorship of design

than $500 per project, and 12% received more than $5000 for at least one project.

Industry sponsors are required to identify a company representative to serve as an advisor to the project. The industry advisor acts as the company contact for the team and is asked to be available to advise teams on issues involving customer needs, provide technical expertise and advice, and approve design concepts and prototypes. Faculty advisors are responsible for administrative issues (grading, monitoring progress of teams, and dealing with team issues) and providing guidance to the team. Communication between the team and the industry advisor can be in person or by telephone, e-mail, or video conferencing. The industry advisor determines the frequency of communication with the team as well as the need for travel.

Teams are required to construct and test prototypes to verify that their design solves the sponsors' problems and meets the sponsors' needs. Students typically have access to the university's computer network, libraries, machine shops, and laboratories. Construction of functional prototypes can be costly, and testing them may require specialized test equipment or software not available to students. Depending on the complexity of the design and the requirements of the sponsoring company, some prototypes can be made of parts obtained from local hardware stores and easily assembled in a dormitory room. Others may use materials that require casting, molding, or other processes that might not be available to students in an academic setting. In these situations, industry sponsors are asked to provide the necessary resources (prototyping facilities or personnel, laboratories, and test equipment) for the team to complete its projects.

Biomedical engineering student Jamie Solum works to build a defibrillator testing device for Engineering World Health.

Benefits of Industry Involvement

Industry sponsors benefit from their involvement in the capstone design course by receiving additional technical resources dedicated to solving a technical problem at a lower cost. They were recently asked, "How did you or your company benefit from sponsorship of a senior design project (at Marquette University)?" Industry representatives pointed out the additional resources the projects gave their companies, which led to faster time to market. They also noted the opportunity to assess the quality of students for prospective hiring. Others noted the fresh perspective teams brought to design projects.

These responses indicate that industry sponsorship can benefit companies with limited technical resources and allow companies to make progress on lower priority projects without diluting their in-house resources allocated to higher priority projects. Working with engineering students can provide companies with a new way of looking at and solving problems. Project sponsorship allows companies to participate in the training of new engineers, advertise their companies on campus, and gain access to a pool of graduating engineers for recruitment.

Challenges with Sponsorship

Industry-sponsored projects present challenges regarding intellectual property. Intellectual property policies vary greatly between institutions. At Marquette University, for example, students own their intellectual property and can voluntarily sign nondisclosure and patent assignment agreements with sponsoring companies as a condition of sponsorship. Each year, a few of our sponsoring companies do not allow any public disclosures (e.g., classroom presentations) of the results of the projects they sponsor. These requests for confidentiality are accommodated through private team presentations to the course instructor and the faculty project advisor, both of whom have signed nondisclosure agreements with the sponsor.

Typical problems with industry-sponsored projects include company contacts not being available to teams when they are needed, industry sponsors changing scope of the project once the project is defined (scope creep), unrealistic expectations as to the amount of work and level of quality that a project team is capable of delivering in two semesters, and sponsor expectations that do not match the course requirements (time, scope of projects, and order of steps in design process, among other activities).

Overcoming Challenges

Experience with the two-semester multidisciplinary capstone design course at Marquette University has shown that certain types of projects are suited for industry sponsorship. The following types of projects typically meet the needs of industry sponsors and students, as well as the requirements of the capstone design course:

- Lower priority projects for which the company lacks resources. This can be attractive to start-up companies with fewer technical resources.

Left to right: Kevin Vincent, Michael Stojanovic, and Andrew Weingart collaborate on testing of a component to be used in a medical device.

Projects that can be completed in eight months or less (required for a two-semester design course sequence).

- Projects involving the development of new-to-the-world products (may be difficult to complete in two semesters but could be appropriate if a proof-of-concept prototype is acceptable), improvements to existing products (new features, revised packaging, new materials, etc.), or process improvements.
- Projects requiring the development of test procedures and the design of test equipment.

Recommendations for project sponsors include the following:

- Agree on funding expectations with the school. Will you reimburse for team expenses or pay a fee upfront to pay for needed items?
- Discuss goals, timetable, and required deliverables of the course. Sponsors need to understand the desired learning outcomes of the course, what the course deliverables are, and when they are due.
- Sponsors need to understand their roles in the project. They need to be available to students for background information, guidance, and design feedback when students need them to be able to meet course deadlines. Sponsors must be aware of students' time commitments to other courses. Sponsors and students should agree on the frequency of meetings and decide if travel is necessary.
- Manage expectations. Try to avoid scope changes (scope creep) that will require additional time and possibly delay completion of the project beyond the end of the course. Don't request additional deliverables beyond what is required by the course. And don't expect students to complete the project prior to the end of the course.

Summary

Industry involvement in capstone design courses can provide many benefits to participating companies and students. Project sponsors benefit from their involvement by receiving additional technical resources dedicated to solving a technical problem at a lower cost. Sponsorship allows companies to participate in the training of new engineers, advertise their companies on campus, and gain access to a pool of graduating engineers for recruitment. Industry-sponsored projects provide students with experience in solving real-world problems of interest to industry and help prepare them for careers in engineering.

References

1. Susannah Howe, "Where Are We Now? Statistics on Capstone Courses Nationwide," in Advances in Engineering Education [online] Spring 2010 (Washington, DC: American Society for Engineering Education, 2010); available from Internet: http://advances.asee.org/vol02/issue01/papers/aee-vol02-issue01-p03.pdf.

To sponsor a senior capstone design project, contact the capstone design instructor at any accredited undergraduate engineering program.

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