Leveraging Industry Sponsorship as a Catalyst for Transformational Change in a Computer Science & Engineering Senior Capstone Design Program

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This paper provides an overview of the Department of Computer Science & Engineering Senior Design Industry Sponsorship Program at The University of Texas at Arlington. The program seeks to pair sponsors from a wide variety of industrial sectors with teams of senior students during a two consecutive semester course series in a manner that is mutually beneficial for the student teams, sponsor, and University. Students participating in the program gain "hands on" experience in real-world problem solving, knowledge of specific industries and markets, and early career professional contacts. Industry sponsors benefit from the ability to evaluate multiple students for potential future full-time employment, as well as access to technical insights gained during the design, implementation, and testing of projects that are custom tailored to the fit the interest of the organization. The University benefits from funding for project equipment and materials, increased industry participation in this and other programs, and direct feedback from current and future employers of alumni. We discuss several topics that may be useful to other program directors who seek to establish similar initiatives within their own institutions, such as identification and retention of sponsors, scoping of projects, student development, faculty mentorship, and intellectual property.

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Introduction

The Department of Computer Science & Engineering[1] Senior Design Program is a two-consecutive semester capstone course series required of Computer Engineering, Computer Science, and Software Engineering undergraduate students. The program was significantly overhauled in 2015 to increase industry and community involvement while improving the overall undergraduate experience. Prior to the rebuild of the course, students worked on faculty-defined department-funded projects with limited relevance to external parties. Additionally, a traditional waterfall model[2] methodology with rigid design phases was used to structure project development. It was recognized that these limitations created barriers to student success and overall final project quality, and thus established a need for change.

The motivation to seek the support of industry partners is based on a mutually beneficial ecosystem model involving the University, student team, and sponsoring organization. The University benefits from external funding for project equipment and materials, as well as feedback regarding the program and other academic initiatives. The student group benefits from industry experience, mentoring, and enhanced project budgets. Finally, the sponsor benefits from technical insights gained during project development, expertise from faculty mentors, curriculum input through membership in the industry advisory board, and access to students for possible future employment. An overview of the sponsorship ecosystem is presented in Fig. 1.

Projects involve a wide variety of contemporary technical topics such as embedded hardware, Internet of Things (IoT), cloud computing, deep learning, etc. Multidisciplinary teams of 4-5 students work to develop functional prototypes according to requirements agreed upon by the project stakeholders (student team members, course instructor, and sponsor).

The program overhaul was performed in three phases. First, the overall program structure and curriculum was updated to utilize modern agile development standards and industry practices in preparation for undertaking externally sponsored projects. Second, a set of pilot projects from early adopting industry partners was undertaken to generate initial success stories and build confidence in the program. Sponsorship funds from the second phase were used to equip the course laboratory space with rapid prototyping equipment, such as 3D printers, electronic test equipment, surface mount soldering stations, etc. Finally, a sponsor recruitment

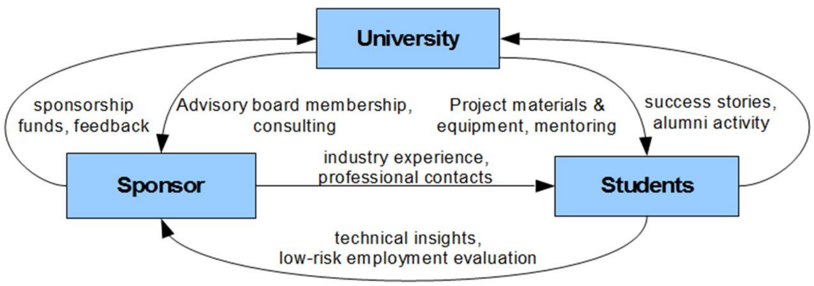

Figure 1: Capstone sponsorship ecosystem

initiative was launched in order to expand the program and generate new departmental contacts. As a result of this undertaking, project quality, laboratory capability, industry involvement in other departmental programs, hiring of graduating students, positive industry feedback, and new alumni participation have all increased.

Program Structure

Students participating in the program have already received most of their undergraduate technical training, but have little or no "real world" industry experience. It follows that students would benefit significantly from training specifically addressing the transitional period between their undergraduate studies and early career activities. Recognizing this unique educational scenario, we have structured our capstone program to simulate the environment of a small engineering design firm. This *"run it like a business"* approach seeks to maximize the compatibility of the academic program with the operations of potential industry partners.

The program consists of a two-course sequence[3] taken in consecutive semesters, so the students can choose from Fall/Spring, Spring/Summer, and Summer/Fall. When forming teams, the instructors (paper authors) ensure each team comprises a mix of Software Engineering, Computer Science, and Computer Engineering majors, while balancing the skills across teams. Each project relies heavily on previous engineering/science classes[4], while also pushing the students' abilities with new concepts not taught in those classes. This simulates work in industry for which employees must learn what is necessary to accomplish the tasks. Throughout development, the instructors provide mentorship for the students.

During the two semesters, the teams us a version of the scrum agile development methodology[5]. Our adaptation of this method uses a two week "sprint," during which students try to complete a goal (without external interference), and an additional week when results are shown/evaluated and the next sprint is planned. This more closely matches common industry practices, where development practices must be flexible enough to accommodate periodic change while allocating time for focused progress.

The students produce several forms of documentation throughout the course sequence, including a Project Charter outlining the "why" and "who" of the project, a System Requirements Specification detailing the customer requirements, an Architectural Design Specification which provides the system architecture, and a Detailed Design Specification containing implementation details. As customer requirements frequently change and unexpected situations can arise that necessitate changes, the documents are treated as living documents and are updated as needed with instructor and sponsor approval. The two semesters culminate in a working prototype that is demonstrated during an event open to the public. At this event, each team displays a poster outlining the project and presents their work to attendees. Each team is required to submit final document versions, all source code and design files, source code documentation, and videos demonstrating functionality.

Given the increasingly pervasive nature of computing in virtually all aspects of modern life, the program can be used as an opportunity to educate students on some of the many career paths where their skills can be of value. As such, we have defined the following thematic areas for senior capstone projects:

- Enterprise – projects of interest to established companies and traditional markets
- Community engagement – projects that create engineering based solutions for nonprofit organizations, charities, and other groups benefitting society.
- Academic outreach – projects that seek to increase the visibility of the University and spark youth interest in STEM fields
- Entrepreneurship – projects that focus on developing prototype technologies with an emphasis on potential commercialization
- Research support – projects that develop testbeds, customized equipment, and experimental implementations of faculty led research
- Open source – projects that create tools, software libraries, and general technologies to be made publicly available.

Note that these thematic areas do not specify any particular industries or markets (Enterprise projects, for example, could involve health care, defense, energy production, etc.).

Identification of Sponsors

One of the biggest challenges in adopting a sponsorship program is identifying industry partners who are willing to participate during the founding semesters. The success stories generated from a mature program will attract future sponsors through word-of-mouth marketing and publicity, but founding members need to be carefully and selectively recruited.

Two effective sources for founding sponsors are existing Industry Advisory Boards (IABs) at the department or college level, and from direct contacts with faculty (often previous collaborators). These types of sponsors will already be familiar with the department and instructors, and generally will have an existing interest in the success of the institution. Additionally, the pioneering nature of a new program will be better understood and expectations appropriately scaled.

After the conclusion of the initial projects, the resulting success stories and lessons learned will allow for expansion of the program and recruitment of new sponsors. Marketing material in the form of a program website, demonstration video, and hard copy flyer linking to media will be extremely useful in this effort. Once this material has been generated, it should be distributed to visitors, existing and potential collaborators, and alumni networks. The goal is to generate inquiries into the program such that the instructors can glean information about the organization's interests and needs.

In addition to actively recruiting new sponsors, a great deal of attention should be focused on retention. Recurring sponsors are ideal for reasons of stability and consistency (i.e., expectations do not fluctuate). A mature program can generate a substantial amount of regular support and additional involvement with the institution from well cultivated relationships. A capstone sponsorship program can also be used as an "entry level" industry-university collaboration, given that the funding and time commitments are relatively low.

Once a sponsor is identified, the instructor needs to make an appraisal of expectations (i.e., what does the sponsor expect to get out of their participation in the program). These expectations can be very different between participants. One sponsor, for example, may hope to talent future employment, while another may wish to gain technical insight on a problem that they are unable to investigate themselves. Additionally, some sponsors will expect a high degree of interaction with the students while others prefer to be less directly involved. Whatever the motivation, the instructor should tailor the project constraints, team membership, and level of interaction accordingly.

Project Selection

Industry sponsored projects must be carefully selected and scoped in a way that balances feasibility with end goals and expectations. Given that sponsors invest funding and valuable time as project stakeholders, the instructor must set a framework for success during initial discussions. Several aspects must be considered prior to finalizing a sponsorship agreement with an external organization.

First, the instructor must ensure that the proposal meets the strategic aims of the program. A business, for example, would likely face significant difficulties when undertaking a project that did not play well to its strengths. Similarly, a capstone project must fit well within one of the previously discussed thematic areas while also providing a valuable education opportunity for students. It is of critical importance that an instructor maintains the ability and willingness to decline proposals that do not meet these criteria.

Second, the technical expectations of the sponsor must realistically match student capabilities and time constraints. Students should be challenged by their tasks, but not overwhelmed to the point of total confusion. The instructor should formulate realistic best and worst-case scenarios regarding the project development such that expectations can be realistically set up front.

Third, a clear description of what participation in the program does and does not entail should be discussed with the sponsor, preferably in writing. The difference between sponsored capstone projects (where funding is provided as a gift to the program) and sponsored research (where binding statements of work are agreed upon) must explained. The instructor must also prevent a sponsorship from devolving into any sort of contract work, as this would be unfair to the students and in direct conflict with the educational goals of the program. All sponsors must understand that no guarantees or formal obligations of any sort will be provided as a condition of their participation.

Instructor Role

In a successful program involving multiple parallel projects with different sponsors, the instructor must tend to critical operational aspects such that the benefits to all participants are maximized and any potential conflicts are effectively mitigated. In our engineering design firm model, the instructor essentially functions as the chief executive officer, providing direction and oversight without engaging in micromanagement.

First, the instructor must communicate regularly with the sponsor during the project lifecycle. This does not replace direct engagement between the sponsoring organization and student team, but rather a supplementary line of communication between the executive stakeholders of the project (i.e., the instructor and the individual designated as the sponsor point of contact). In practice, we reach out to sponsors directly on a monthly basis to receive feedback and gauge their level of satisfaction with the current status of the project. This approach allows us to make real-time adjustments while also providing an opportunity to further develop the relationship between the sponsoring organization and academic institution.

Second, the instructor must provide executive level oversight and professional mentoring of the student team. This is achieved by a combination of classroom activities (sprint planning and sprint review presentations) and direct discussions with the students. The lab provides an ideal opportunity for gleaning such information through impromptu interaction, especially if the students are encouraged to use the space as a base of operations during their time in the program. Specifically, the instructor should try to get the students' perspective on project progress, communication with the sponsor, and any other concerns that may not present themselves during scheduled class activities.

Third, the instructor must be available to provide technical guidance when necessary. This presents some unique challenges with respect to more typical undergraduate courses, since the requirements and requisite skills for each parallel project will often be quite different. The instructor should strive to steer students toward feasible solutions and help to work around technical roadblocks while allowing the student teams as much autonomy as possible. Given that failure is a critical part of the engineering learning process[6], the instructor should not seek to prevent all student mistakes or suboptimal design decisions, but rather they should seek to mitigate the consequences and maximize the learning outcome of non-critical failures.

Finally, the instructor must maintain mastery over the logistical requirements of the program. The lab space, if available, must be adequately equipped and stocked with student access updated as necessary. Ordering of parts and equipment from sponsorship funds and student budgets must be performed in a timely manner, which may "peak" at certain times during the semester (it may be beneficial to adopt an online support ticket system for management of student purchases and lab maintenance requests, such as Hesk[7] or osTicket[8]). Any external events, such as project demonstration sessions or meetings with potential sponsors, must be scheduled and coordinated appropriately.

Ultimately, the success of the program depends upon the ability of the instructors to manage these roles and strike a balance between active involvement and student autonomy. As the program matures from a pilot initiative to an efficient establishment, instructors will naturally make necessary adjustments and improvements to reach maximize efficiency.

Results

In the first semester after the initial course rebuilding phase, two founding industry sponsorships were secured. These projects resulted in successful final demonstrations and full-time employment for two graduating students (one from each team). Four sponsorships were secured in the following semester with similar favorable results. The total amount of supplementary funds contributed by sponsors during the founding academic year was roughly $30,000, which was immediately invested in prototyping equipment, tools, and infrastructure upgrades for the lab.

During the second year of the program, seven sponsored projects resulting in an additional $35,000 worth of supplemental funds were secured. Again, these funds were used to expand lab capabilities and capacity to meet the demands of growing departmental enrollment.

To date, nearly $100,000 of funding over the first three years of the program has been pledged. This has corresponded with substantial increases in overall project quality (due to increased lab capability), repeat industry participation, job placement for alumni, and positive feedback from project sponsors and IAB members. Similarly, compared to semesters before the changes, the department has received more favorable student feedback from both internal departmental exit surveys and student interviews we collect to prepare for ABET accreditation[9]. We are currently exploring the possibility of expanding the model to other departments, integrating the program into larger strategic initiatives, as well as integrating feedback from graduating students and alumni[10].

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