Faculty Perceptions of Industry Sponsorships in Capstone Design Courses

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Abstract

Many studies have established the value of industry partnerships in engineering capstone design courses. Students are often identified as the primary beneficiary of these collaborations. Students benefit from exposure to professional practices, as well as non-engineering constraints (e.g. economic, legal, regulatory). Furthermore, students are able to develop a professional network. Industry sponsors are identified as a secondary beneficiary of these collaborations. Sponsors gain access to faculty expertise, as well as increased interactions with students that may inform offers of employment more so than traditional resumes and interviews. Lastly, the school/program benefits from these collaborations that provide feedback to improve curriculum, and in some cases can lead to program funding and/or capital investments. Faculty are rarely considered as potential beneficiaries of these industry collaborations. However, faculty engagement has been linked to student engagement, which is strongly tied to student learning. Faculty behavior and attitude have great potential to affect student motivation and academic gains across the curriculum. Therefore, faculty engagement may play an important role in the success of industry partnerships within capstone design courses that has been neglected in previous work.

This work aims to gain preliminary understanding of what facets if capstone projects influence faculty engagement in industry partnerships, and how these facets contribute to program-level fostering of industry sponsors in the curriculum. In the past 2 years, acceptance of increases in industry sponsorship has varied greatly between programs within our school. Faculty across all school disciplines (civil engineering, electrical engineering, mechanical engineering, and computer science) were surveyed to assess perception of faculty benefits and weaknesses of industry sponsorships within each discipline's capstone courses. This individual feedback was coupled with interviews and differences in higher level program interactions with the school's industry relations manager. Collectively, this information may provide potential mechanisms to incentivize individual faculty engagement in industry partnerships, foster overall program and school support of these collaborations, and serve as a model for extending this work to other institutions.

Introduction

Industry partnerships in capstone design programs have increased substantially over the past few decades. Studies have highlighted how these partnerships can be beneficial to multiple stakeholders [1], [2]. Working with industry partners can benefit students, engineering programs and partnering companies. However, potential benefits to faculty are rarely considered. Based on the critical role faculty play in student engagement and learning, more consideration of faculty engagement within capstone programs may enhance student learning and engagement.

For students, industry partnerships in capstone are seen as providing an intersection of students' academic learning and their future careers in industry. Our institution supports sponsored projects that can prepare students to approach open-ended problems, improve design

and communication skills, incorporate stakeholder needs, and work effectively on teams. The connections they build with industry partners can also be the beginning of a professional network. Furthermore, experience working on a real-life project can help students identify or clarify their career path within engineering.

For engineering programs, these industry partners can serve as a resource to benefit many different campus efforts. Feedback from companies to faculty informs curriculum development and promotes industry relevance [3]. In some cases, sponsorships from partnering companies can provide direct financial support for project materials and equipment. Additionally, industry partners can act as a part of the institution's broader professional network to connect graduates and alumni to employment opportunities.

For partnering companies, capstone sponsorship can provide a meaningful way to engage with the future of engineering. Their participation can serve as an investment in their future workforce, as well as an opportunity to access unconventional solutions from students and faculty. In some cases, partnering companies can provide meaningful feedback to shape curriculum to meet their workforce needs [4]. This extended project partnership throughout an academic year also gives industry partners a chance to see students in action, assessing their fit and capabilities for full time jobs.

Although the benefits of industry partnerships to students, engineering programs, and partnering companies have been established, an additional stakeholder in this partnership with industry—the faculty advisor—has rarely been considered. Faculty engagement has been linked to student engagement [5], [6], which is strongly tied to student learning [7]. Faculty perception of industry sponsors in capstone is an important component to consider when evaluating the benefits of industry partnership. Faculty attitudes toward sponsorship have great potential to positively or negatively affect student motivation and learning. Therefore, faculty engagement likely plays an important role in the success of industry partnerships within capstone design courses.

Over the last 3 years, the authors' institution has made significant changes in the capstone program, not least of which is the increase of industry sponsored projects from 0-80%. Acceptance of increases in industry sponsorship has varied greatly between programs within the school. The aim of this work was to understand the motivations of faculty within the context of advising capstone teams, as well as their perception of benefits and challenges of industry sponsorship in capstone. This information may inform future changes within the capstone program to optimize faculty engagement that will likely positively influence student engagement. Furthermore, engaged faculty are needed to foster overall program and school support of these collaborations.

Methods

Faculty from all school disciplines (civil engineering, electrical engineering, mechanical engineering, and computer science) were invited to complete a survey (n=17, 55% response rate) that assessed perception of faculty benefits and weaknesses of industry sponsorships of capstone projects. The survey included questions about prior roles and responsibilities within capstone

projects, potential incentives for increasing faculty engagement, as well as potential benefits and concerns related to externally sponsored capstone projects (Appendix).

The first set of multiple-choice questions recorded the faculty's discipline, the number of teams advised and if they had advised a team with an external sponsor. The remaining sections of the survey included statements related to incentives, benefits and concerns of projects rated on a 5-point Likert scale from strongly disagree to strongly agree.

After reviewing survey results, 3 faculty members that had previously expressed non-anonymized opinions related to industry sponsorship of capstone projects were interviewed. These 3 faculty members were from 3 different disciplines: computer science, electrical engineering, and mechanical engineering. They represented opinions that included: strong support of industry sponsored capstone projects, strong resistance, and a transition from resistance to support, respectively. Computer science and mechanical engineering programs have participated in more industry sponsored capstone projects, compared to the electrical engineering program. Participation in industry sponsored capstone projects is determined by faculty within each program. Therefore, these conversations provided insight into individual experiences that shape faculty perceptions within their program, as well as features that contribute to the "best" projects. This information provided many comparisons between facets of sponsored and non-sponsored projects within different programs.

Results

When considering the entire school, faculty survey responses were somewhat similar for most statements assessed. Faculty within each discipline responded with similar agreement or disagreement for 8-9 of the 12 statements assessed. Those statements with differing responses among faculty members occurred in multiple disciplines.

Within the survey, many faculty members agreed that proposed incentives related to advising capstone projects (sponsored or non-sponsored) had a positive influence on their engagement in the process (Table 1). However, comments obtained during interviews differed from survey results. All faculty interviewed agreed that the credit load offered was proportional to time spent advising the team, but the presence or absence of credit load had very little influence on the time they were willing to dedicate to advising a capstone team. All faculty interviewed agreed that the project topic was important to the success of a capstone project, but not for the reasons assessed in the survey. They indicated that student passion and engagement for the topic were of primary importance to a project's success. Furthermore, one interviewed faculty member reflected on their own experiences as a student being engaged by interactions with passionate faculty in their prior engineering education.

Table 1: Survey responses related to faculty incentives for advising capstone projects. Responses are reported as percentages of the total number of responses.

	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
Course credit associated with advising capstone teams positively influences my engagement in advising.	53%	24%	12%	6%	6%
Influence of project topic (i.e. faculty project or faculty connection to external sponsor) positively influences my engagement in advising.	47%	35%	12%	6%	0%

Many faculty members agreed with nearly all surveyed potential advantages of working with industry sponsors (Table 2). However, faculty had mixed opinions regarding advising a sponsored project as an opportunity to stay current in the field (Q2). Each interviewee noted the students' exposure to real-world problems, potential for working on something with real stakes and real impact, and opportunity to learn professionalism/communication skills as the main benefits of industry sponsored projects. They also noted that external projects create an accountability for all students within the team that is hard to replicate with a student-proposed or a faculty-proposed project.

Table 2: Survey responses related to potential benefits of externally sponsored capstone projects. Responses are reported as percentages of the total number of responses.

	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
Q1: Advising externally sponsored capstone projects is an opportunity for me to expand my professional network.	29%	41%	18%	12%	0%
Q2: Advising externally sponsored capstone projects is an opportunity for me to stay current in my field.	6%	47%	24%	24%	0%
Q3: Advising externally sponsored capstone projects is intellectually stimulating for me.	35%	41%	18%	6%	0%
Q4: Externally sponsored capstone projects increase student motivation and productivity, which is important to me as a faculty member within the school.	47%	47%	6%	0%	0%
Q5: Externally sponsored capstone projects expand students' professional networks and increase opportunities for hiring, which is important to me as a faculty member within the school.	76%	18%	0%	6%	0%

Most surveyed potential concerns related to industry sponsorship in capstone were not strongly held perceptions of faculty (Table 3). Faculty surveyed disagreed with nearly all statements related to concerns. The one concern that had varied responses from somewhat disagree to somewhat agree was that sponsored capstone projects require more work for faculty advisors and decrease flexibility of deliverables (Q4). Challenges noted by the interviewees echoed the potential lack of student passion for a project from industry that they are assigned to, as well as the potential lack of faculty passion for a project with a similar assignment process. One interviewed faculty member expressed concerns for diminishing key academic lessons within industry projects that may lack requirements for "real" engineering modeling and application of engineering principles, instead allowing students to employ trial and error via CAD modeling.

Table 3: Survey responses related to potential concerns of externally sponsored capstone projects. Responses are reported as percentages of the total number of responses.

	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
Q1: Externally sponsored capstone projects are influenced by money that prioritizes industry needs.	6%	12%	29%	41%	12%
Q2: Externally sponsored capstone projects diminish key academic lessons of the capstone course.	0%	0%	18%	18%	65%
Q3: Within externally sponsored capstone projects, student interactions with a client have the potential to be demoralizing. These real-world lessons in failure should be deferred until after graduation.	0%	0%	6%	35%	59%
Q4: Externally sponsored capstone projects require faculty advisor accountability, which can increase faculty workload and decrease flexibility of deliverables.	6%	41%	29%	24%	0%
Q5: Rapid change in the number of externally sponsored capstone projects has negatively impacted the quality of student learning within capstone courses.	6%	0%	12%	18%	65%

Discussion

Faculty from all disciplines were invited to complete a survey assessing perception of externally sponsored projects. Those faculty that completed the survey generally agreed with most proposed benefits of externally sponsored capstone projects and disagreed with most proposed concerns. Exceptions to these trends included disagreement that advising externally sponsored projects is a way to stay current in their field (Table 2, Q2) and agreement that externally sponsored projects may increase faculty workload and decrease flexibility of

deliverables (Table 3, Q4). Follow-up interviews yielded more specific details and experiences that contributed to survey perceptions.

Perceptions of credit associated with advising varied between the survey and interviews. Survey results indicated agreement that credit positively influenced faculty engagement. However, interviewed faculty said credit had very little influence on the time they dedicated to advising. Interviewees agreed that the credit accurately reflected the amount of time spent on projects. While they appreciated their course load reflecting their involvement, all interviewees noted that they likely would spend the same amount of time with a team without credit. This acceptance may be attributed to previous practices that did not offer credit for advising teams prior to 3 years ago.

All interviewed faculty cited student passion and engagement as key components toward their satisfaction in advising capstone teams. Regardless of sponsorship, each faculty member recalled projects where students connected as a team and had excitement for their project. In these cases, the team was motivated to set and maintain the pace of forward progress. Students viewed their faculty advisor as a resource to consult with when they needed help. These motivated and engaged students who care about the project make projects particularly enjoyable for faculty to be involved with.

A unique trait of an externally-sponsored project is that it requires participation from outside of the university. While it is enjoyable for faculty to step away from everyday coursework to be part of a team solving real-world problems, faculty recognize that they cannot direct sponsored projects alone. The sponsor must provide an industry advisor to work with the team to develop a successful project.

If student engagement can't be directly achieved by project topic, faculty engagement within the project topic may serve as a suitable alternative mechanism. One of the interviewees reflected on their own experiences as a student assigned to a project. Although they were not familiar or interested in the topic initially, their faculty advisor's passion was motivating and helped them develop interest in the project. This experience is consistent with prior studies [5].

Many faculty members appreciate professional development opportunities embedded within capstone courses. Survey results indicate agreement that externally sponsored projects contribute to expand faculty and student professional networks, both of which contribute to student employment. Two of the interviewed faculty echoed this support by highlighting professionalism and accountability demonstrated by students within externally sponsored teams. Students had an appreciation for the value of others' time. In some cases, their work can be an 8-month job interview if the sponsor is looking to hire. Despite these benefits, one interviewee questioned whether students should gain exposure and experience in these professional skills during their undergraduate program, particularly if it's at the expense of focused applications of engineering principles. These concerns are shared by other faculty in the school, but may be broadly related to differences between industry's needs and academia's goals [8], [9] across the entire curriculum, not just capstone courses.

Multiple interviewees perceived their discipline's capstone course to require more from their students than all other programs within the school. Faculty believe that these differences contribute to differing levels of student outcomes and experiences between disciplines. While it's highly unlikely that the 3 disciplines surveyed each have the most rigorous capstone requirements within a school of 4 disciplines, there are several actions that can be taken to increase transparency, as well as mutual understanding and respect, between disciplines. For instance, one program has developed a faculty advisor handbook that details standardized expectations. This handbook may serve as a model for other programs to adopt. Similarly, consistent content requirements and grading standards across all disciplines may promote consistent experiences for students.

The authors acknowledge that this work is the result of a subset of faculty from a single institution. Therefore, extrapolation of reported results is extremely limited. However, the authors believe most educators value student engagement, as well as mechanisms to maximize it. This work is intended to promote discussions within the engineering education community to examine faculty's role in student engagement, particularly within capstone. The authors welcome other institutions to investigate and share findings related to this effort.

Conclusions

Regardless of sponsorship, the most prevalent feature that has contributed to our faculty's satisfaction and the perception of a successful project is student investment or buy-in. If all externally sponsored project were well suited to students' interests and passions, industry sponsorship would be more widely accepted and supported by faculty within our institution.

Toward this goal of unanimous student engagement, our institution's capstone committee is considering requesting a list of 3-5 well-scoped, proposed projects from each industry sponsor. This will provide students with the opportunity to choose which topic their team will address, which may increase their sense of ownership of the project. One potential challenge with this approach is the increased work placed on sponsors to generate multiple projects that may not be chosen to pursue.

We acknowledge that it may not be possible to match every student with a project that they are passionate about, particularly in the case of students with broad or ill-defined interests. In these cases, it is important to increase the engagement of our faculty advisors within the project topic. Engaging faculty within the project may have positive effects on student engagement. Typically, a single instructor from each discipline assists in scoping proposed projects. Engaging all prospective faculty advisors earlier in this formative stage could guide project development and increase faculty advisor engagement. One potential challenge with this approach in our institution is that faculty load currently determines advisors for capstone teams, particularly who will advise multiple teams based on who has open credit load, not necessarily based on who is best suited for each proposed project.

All future modifications of our capstone program will be focused toward increasing student engagement to promote project success. This work has reaffirmed that one mechanism to increase student engagement is through engagement of our faculty. The authors encourage other

institutions to consider faculty engagement within their capstone programs and to share their findings with the engineering education community.

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Appendix: Faculty Survey

Thank you for agreeing to take part in this faculty survey evaluating opinions related to externally-sponsored capstone projects. Your feedback is important to guide future efforts to engage stakeholders and shape the capstone program. This survey should take less than 5 minutes to complete. All responses will remain anonymous. Aggregated data may be used as part of an engineering education conference abstract and/or presentation.

Which department are you part of?
Response: Civil Engineering, Electrical Engineering, Mechanical Engineering, Computer Science

How many capstone design teams did you formally advise during the 2018-2019 academic year?
Response: Enter a number 0, 1, 2, etc.

Did at least one of your design teams in 2018-2019 have an external sponsor?
Response: Yes, No

Have you been a capstone instructor of record during the 2017-2018 or 2018-2019 academic years?
Response: Yes, No

Please review the following statements related to faculty engagement in all capstone projects (i.e. faculty projects, student projects, external projects). Please rate how strongly you agree or disagree with each statement.
Response: Strongly Disagree, Somewhat Disagree, Neutral, Somewhat Agree, Strongly Agree

- Course credit associated with advising capstone teams positively influences my engagement in advising.
- Influence of project topic (i.e. faculty project or faculty connection to external sponsor) positively influences my engagement in advising.

Please review the following statements related to potential faculty benefits of externally sponsored capstone projects. Please rate how strongly you agree or disagree with each statement.
Response: Strongly Disagree, Somewhat Disagree, Neutral, Somewhat Agree, Strongly Agree

- Advising externally sponsored capstone projects is an opportunity for me to expand my professional network.
- Advising externally sponsored capstone projects is an opportunity for me to stay current in my field.
- Advising externally sponsored capstone projects is intellectually stimulating for me.
- Externally sponsored capstone projects increase student motivation and productivity, which is important to me as a faculty member within the school.
- Externally sponsored capstone projects expand students' professional networks and increase opportunities for hiring, which is important to me as a faculty member within the school.

Please review the following statements relating to potential faculty concerns about externally sponsored capstone projects. Please rate how strongly you agree or disagree with each statement.
Response: Strongly Disagree, Somewhat Disagree, Neutral, Somewhat Agree, Strongly Agree

- Externally sponsored capstone projects are influenced by money that prioritizes industry needs.
- Externally sponsored capstone projects diminish key academic lessons of the capstone course.
- Within externally sponsored capstone projects, student interactions with a client have the potential to be demoralizing. These real-world lessons in failure should be deferred until after graduation.
- Externally sponsored capstone projects require faculty advisor accountability, which can increase faculty workload and decrease flexibility of deliverables.
- Rapid change in the number of externally sponsored capstone projects has negatively impacted the quality of student learning within capstone courses.