Motivations and Perceptions of Capstone Benefits for Industry Sponsors and Academic Advisors: A Retrospective Study

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The goal of this research is to understand and explore the motivation and value that industry gains from sponsoring senior year mechanical engineering capstone design projects at Clemson University. This research compares capstone projects' expected values from the perspectives of both the sponsoring companies and university faculty. Understanding where the value of capstone projects with respect to sponsors will allow faculty to more easily generate sponsor-based projects. Moreover, faculty can use this research to enhance their projects to better align with sponsor needs. Interviewing was used as the data collection gathering method to explore faculty and company sponsor perceptions regarding the capstone design program. Further, retrospective comparisons are made regarding the perceived benefits between capstone faculty members and the sponsor company. Conclusions of this work show that faculty anticipates companies to return to sponsor projects, especially if the final product generated by the student teams are beneficial to the company. Companies tend to gain the most value from sponsoring capstone by providing low priority projects to provide solutions with minimal investment.

Keywords: Capstone benefits, Capstone perceptions, Interviewing

Motivation for Understanding Capstone Benefits

The overall goal of this research is to understand and explore the motivation and value that industry gains from sponsoring senior year capstone design projects in the department of mechanical engineering at Clemson University. The values of these projects are compared from the perspectives of both the industry sponsors and university faculty. After exploring research on capstone programs by several universities, papers from Todd and Durkin mention feedback of the program from the sponsors[1-3].

Ninety-two percent of Clemson University mechanical engineering capstone design projects are industry sponsored. In order to build and improve existing relationships with industry-sponsored projects, it is necessary to know what these companies perceive about the program. Moreover, this feedback can be useful to implement changes in basic introductory design courses. Figure 1 shows the goal of this research, which is to understand how well the perceived incentives from company sponsors and capstone faculty (ME 4020) align. Is there a separation of the expected benefits from industry sponsors and capstone faculty and if so, how does this affect the project? If the benefits in sponsoring capstone design projects are different from the faculty members' perception, then there is an opportunity for faculty to improve their sales pitches when approaching industry for new projects. Theoretically, these techniques would be applicable for previous, current, and future industry sponsors of capstone. Moreover, if some of the benefits perceived by both are the same, then it reveals that capstone faculty are providing what industry sponsors want. The student perception of the value in capstone design projects is also discussed as part of this research.
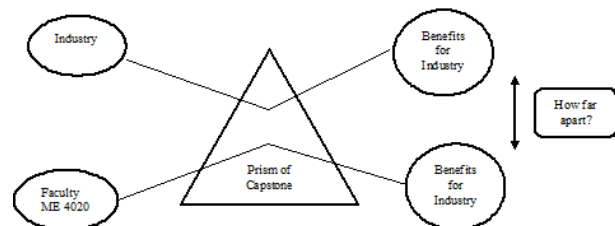

Figure 1 Research overview and goals

Data Collection Method

Figure 2 shows the basic structure for this research into perceived benefits of the capstone program.
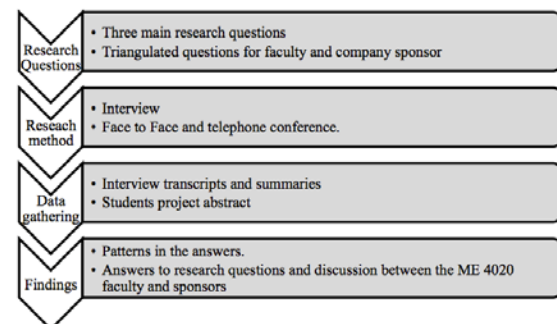

Figure 2 Research approach

In short, the main objective of this research is to explore the viewpoint of both faculty and industry sponsors with respect to the value of sponsoring a capstone project (ME 4020 at Clemson University). Interviewing is used as the method of data gathering using two semi-structured sets of questions – prepared separately for faculty and sponsors – and triangulated within in order to answer the research questions.

Interview Design

Interviewing is a widely accepted method in qualitative research, this can be seen in Claudia Eckert's work[4], which describes a list of 30 papers that used interviewing for educational design research. Gable[4] suggests that interviewing can help ask penetrating questions which helps in querying the interviewee with leading questions and retrieving thoughts regarding capstone. In addition, asking these questions can lead to more elaborative answers that are not as prevalent through the use of surveys. The ability to read facial expressions and body language, making eye contact or hearing the vocal tones while in telephone interviews are essential nonverbal cues that are advantages of interviewing, as suggested by Lokman[6]. These techniques and processes (Figure 3) help provide extensive responses from interviewees that can be used for engineering research.
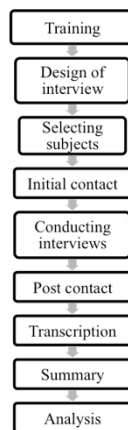

Figure 3. Interview design process

A semi-structured interview process was followed to interview seventeen participants: six university faculty and eleven company sponsors. Professors from Mississippi State University, Colorado School of Mines, and Clemson University were interviewed. Also, industry sponsors from Techtronic Industries, Michelin, Corning Cables, General Electric, Parker Hannifin, Schneider Electric, and Okuma America Corp were interviewed to receive their feedback regarding capstone. Although not a statistical large sample of thirty, good practice suggests that interviewing should continue until new, surprising findings were no longer found, as seen in the ethnography study by Gold[7] and Shankar et al.[8]. Thus, appropriate

saturation was achieved after six professors and eleven industry sponsors were interviewed. All interviewees have more than seven years of experience in their respective fields.

All interviews were based upon the same subjects with slight varying of questions. By allowing the questions to slightly vary between participants, this allowed the interviewer to create more of a conversation and pull more beneficial information from the interviewee with the aid of direct probing[6].

Interview of University Faculty

Two professors were interviewed from the department of mechanical engineering at Clemson University, one from the department of industrial engineering at Clemson University, one from the department of bioengineering at Clemson University, one from the department of mechanical engineering at Colorado School of Mines, and one from the department of mechanical engineering at Mississippi State University. The faculty from other departments and schools were queried in order to explore if the other departments/schools have the same perception about the value for industry. This provides a larger participant pool to triangulate responses and determine the perceived benefits on a broader scale. The interviewed professors have proficient experience with capstone design as a result of heading of their respective programs.

The four primary categories professors were interviewed on are described below:

- Motivation – The purpose of a company/sponsor to offer/support senior year design projects for the capstone design program.
- Value – The perception of the importance and benefits to the sponsoring company.
- Project aspects – Questions related to various project aspects such as program structure, scope, duration, multiple team/field dynamics, and project scale and complexity.
- Retrospective – Memory based questions related to the respondent's memory of the events.

Interview of Industry Sponsors

The selection of company liaisons for interviewing was made from a list of eighty-three previously company sponsored projects from 2004-2014. This list, along with the prior experience and knowledge of the faculty advisor, was used to select company liaisons for the research interviews.

As with the interviewing of university faculty, questions were subdivided into four categories for the industry sponsors. These are highlighted in the following list:

- Memory and experience – Requests respondent answer questions on a specific project from memory.

These questions also query into the background and experience of the respondent.

- Project aspects – This type of question is related to the project structure, duration, and multiple team/field dynamic.
- Project outcomes – The final solutions of the projects are discussed with their impact for the corresponding company.
- Motivation – The perception of the company liaison regarding the purpose of sponsoring senior year design projects for the capstone design program.

Interviewing Results and Discussion

Results from various topics regarding company resources, project outcomes, and sponsor selection in each interview are discussed from the perspectives of both the industry sponsors and academia faculty.

Company Resources

One benefit that sponsors from Parker Hannifin, BMW, Michelin, and Okuma mentioned is that they could save their company time and money by sponsoring projects and having students perform the engineering. Two faculty members did not mention the benefit of a company saving the time and money in hiring full time engineers or outsourcing projects for creative solutions.

Project Selection

All interviewed companies see benefits in using the capstone program as a tool to solve low priority projects and linking them to their continuous improvement practices. Also, nine of the eleven sponsors mentioned the benefits in sponsoring multiple teams for a project, giving them a quality output in terms of multiple solutions for their problem. It can be interpreted that company sponsors see benefit from providing projects that are less time sensitive, need creative solutions faster, and are not necessarily challenging in terms of moving toward a solution.

The company sponsors did not respond on picking diverse and challenging projects for the students to work on, while one professor stated that projects should be diverse and challenging.

Sponsor Selection and Communication

An additional facet to selecting capstone sponsors is that the distance between the university and the sponsor can be challenging for the students to satisfactorily complete projects. Five of the six interviewed faculty members found long-distance projects as logistically challenging for students. The outlying faculty believes that the project scope and the commitment of the project sponsor are more important than the distance of the sponsor from the university. The majority of interviewed faculty members believe it to be taxing on the company for student site visits and thus adding an unnecessary challenge of communication between the students and the sponsors. Techtronic Industries, Michelin, and Parker Hannifin mentioned the importance of student/company interaction with site visits for students to work on problems more closely.

Departmental Benefits

There is a difference of opinion between the engineering departments in terms of the students performing capstone projects. Bioengineering sees value as students complete their own projects to develop their entrepreneurial potential. Moreover, there are few bioengineering companies in the vicinity of Clemson University, which adds another challenge in getting sponsors for the program. Mechanical and industrial engineering preferred sponsored projects, as these are more apt to real-world situations having a need-based customer to work for.

Project Outcomes

It can be concluded from the patterns that the capstone design program has an impact on the companies sponsoring the projects. Faculty members see a high value in the capstone design program, as they perceive that the program is beneficial to both the students and the company sponsors. Similarly, company sponsors have a similar opinion on the value that the students and companies get from the capstone design program. Specifically, faculty stated that a benefit for the companies is the new and varied ideas, with nine of the companies agreeing that they benefited from quality solutions from multiple teams either as comparing alternative solutions (Figure 4) or for exploring different directions (Figure 5). Moreover, all but one of the interviewed company sponsors had positive feedback on the students' deliverables. This explains that there is an overall impact of the capstone program on the company sponsors. Multiple teams on projects are beneficial for providing multiple solutions for the company sponsors.
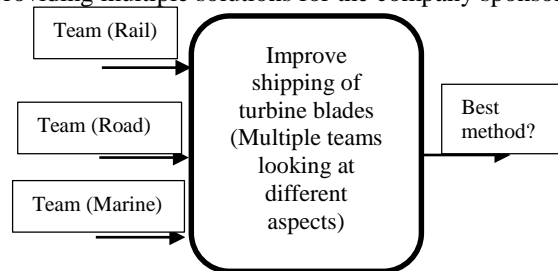

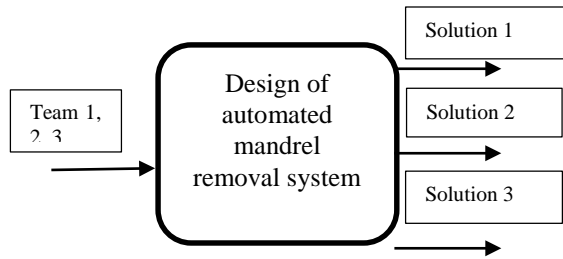**Figure 4: Multiple teams working in parallel**

Figure 5: Multiple teams working for same concept

Additionally, there are instances where faculty members are typically more interested with the student learning outcomes as they want the students to develop in their education and apply it practically while company sponsors tend to care about the final deliverable from the student projects.

Conclusion

Capstone faculty members and the company sponsors have an alignment of perceived benefits as a company sponsor regarding quality output and company publicity when sponsoring capstone projects. It is understood from the interviews that company sponsors will return to sponsor a project as long as the quality of the final product is of their acceptance. Also, the interviewed faculty members that head their programs understand the benefits that companies receive from sponsoring projects. This at least partially explains how faculty have been able to ensure industry will sponsor capstone projects, which can be another factor in the success of getting projects from other sponsors.

In terms of student outcomes, students should apply their prior knowledge and think critically by applying their analytical skills in the capstone program. Company sponsored projects are an effective way of applying their skills, eventually giving students real world experiences. It is also suggested that capstone design is the best way for a company to solve low priority problems with minimal investment. If not all project requirements are met, industry sponsors still can retrieve new design concepts with the bonus of determining the ability of potential future employees in terms of their quality of work from the projects, or indirectly in terms of building company reputation within the department and university.

Future Work

This research interviewed faculty members and company sponsors regarding their thoughts related to capstone design programs. However, to have more complete feedback of the capstone program, students should be interviewed regarding their perceptions towards capstone. Also, student experiences post-capstone should be investigated for a more well-rounded analysis of the perceived benefits of capstone.

Also, surveys can be used to gather more data to investigate the previously discussed topics. This would especially be useful for certain questions where great elaboration is not required but statistical analysis can be performed to determine the overall perceived value of each question to students, faculty, or industry sponsors. Moreover, the timing of the surveys is of interest to see how perceptions change over time.

The financial output that companies receive from sponsoring projects is another area to investigate. The financial return on investment from any sponsorship fees is not determined in this research. The companies that responded to have used the solutions of the students can be investigated further to determine how they have financially benefited (or not) after implementing student-generated solutions. Moreover, do companies consider financial output benefits with the quality solution that they receive?

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