



Industry and Students Perception of Capstone Projects

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Abstract

Capstone projects are designed to help students learn technical, communication and interpersonal skills that will ultimately provide them with a broad knowledge base required at the start of their professional careers. Engineering capstone experience prepares students to work in a productive manner in teams. It is expected that the students will learn problems solving, critical thinking, team work and business acumen which will benefit them in finding internships, cooperative experiences and jobs. In today's competitive environment managing expectations of employing companies as well as graduating engineering students is a challenging task. To bridge the gap between industry needs and student training, it is essential to periodically survey the student's understanding of capstone projects and compare it with expectations of employers. This task will ensure that our engineering graduates are well rounded and can become contributing engineers at their respective companies.

The manuscript describes the opinions, perceptions and expectations of capstone project (ME 461 and ME 462) by graduating Mechanical Engineering students and compares it with the views and expectation of recruiting firms and hiring managers. The survey also identifies important components of capstone projects that can be modified and improved to strengthen the current format of capstone project. This work will help to better prepare students for industry careers and create an effective environment between academia and industry requirements.

Introduction

In the last three decades U.S. industry and manufacturing sector has gone through tremendous changes. The manufacturing philosophy, worker expectations and compensation, and affinity to particular geographic location have all changed. Manufacturing sector has become very competitive at a global level. The information technology has further empowered industry with knowledge and tools required to handle complex problems in a timely fashion. Companies tend to explore all alternatives, manufacturing databases before making a meaningful decision that can impact their revenue over long term. All these changes have impacted the industrial manufacturing process and the labor force, especially engineers working with the multi-national companies on collaborative projects. Now manufacturing companies are looking for well-rounded engineers who can think critically and solve complex problems, in a multi-disciplinary team, while working in a fast paced environment. Engineering education has a significant role to play to produce such qualified engineering. The course curriculum has to be developed in a manner that imparts students the basic engineering knowledge and skills required to handle industrial and manufacturing projects in a successful manner. One of the professional skill building tools is the introduction of cap stone projects (CSP's) into undergraduate engineering education. CSP's helps to prepare students to meet some of the high expectations of the engineering firms (Goldberg, 2011).

Background

CSP's in engineering education are not new; most technical colleges include these projects to their engineering curriculum. Past research has found them to be an effective tool in helping students to prepare for challenging careers in manufacturing sector. As manufacturing companies objective is to design and manufacture high quality products at a minimum cost in a fast paced environment, they are now more interested in the workforce who understands what is required for the growth and profitability of the company. The present issue faced by industry and manufacturing sector is not the number of students but well qualified and trained engineering students (Deleveaux & Ruud, 1997).

A few earlier studies have highlighted some of the major weakness of the engineering students as identified by the manufacturing industry (Hood, Sorensen, & Magleby, 1993, Trent & Todd, 2012). The deficiencies include effective interpersonal and communication skills, project planning, time management, multi-disciplinary knowledge, teamwork, budget planning and engineering economics (Hood 1993, NCML, 1996). To overcome these challenges and deficiencies most of the technical schools and engineering colleges have introduced a senior design or CSP course that gives students an opportunity to learn and earn credit and get real world manufacturing experience while studying in the college (Todd, Sorensen & Magleby, 1993). CSP course is designed to attract small projects sponsored by industry or research faculty projects that can be worked by junior or senior level engineering students under guidance from the industry experts or their instructors. Overall focus of these projects is to improve the problem solving skills of American engineering students and expose them to real manufacturing world where they can apply the social, technical, practical, financial and project management skills learned in the classroom.

Importance of CSP's

The CSP's provide an opportunity to develop and improve engineering work force requirements, such as technical skills, system design and constraints, efficiency improvement, communication, work ethics, training efficiency etc. The core competencies extend beyond technical ability to include understanding stakeholder expectations, effective communication skills, planning, resource allocation, time management, budget planning, teamwork, anticipating risks, weak links and financial aspects of the business.

Currently most of the engineering disciplines offer either one semester or two semester structured CSP's. The project team comprises of 3-4 students. Grading is based on the teamwork accomplishment, project planning and execution, system design, best solution to a problem, budget preparation, prototype development and demonstration and finally report writing and presentation of their work to the peers. The CSP problems assigned to the students are small industry sponsored projects, new design project, or faculty research projects. At North Dakota State University (NDSU), Department of Mechanical Engineering, ME 461/462 courses offer senior design project experience. In the first semester students focus on project planning, system design and budget planning. System design component is aimed at developing critical thinking, understanding the constraints and identifying the best solution. At the end of the first semester they present their work to mentors and classmates for their review and feedback. In the second semester students order parts and design the prototype unit. They demonstrate its operation accompanied by a final project report to mentors. They are encouraged to share the strengths and

weaknesses of their prototype system. These CSP's offered by Mechanical Engineering department are designed to help students to apply technical knowledge; improve interpersonal communication skills, project planning and scheduling, teamwork that will ultimately provide them with a broad knowledge base required at the start of their professional careers. It is expected that the students will learn problems solving skills, critical thinking, teamwork and develop business acumen. Finally these skills will benefit them in finding internships, cooperative experiences and exciting jobs. In today's competitive environment managing expectations of employers as well as graduating engineering students is a challenging task. To bridge the gap between industry needs and student training, it is essential to periodically survey the student's perception of capstone projects and compare it with expectations of employers. This study focuses on understanding the perceptions of CSP's by engineering students as well as the manufacturing industry. It is expected this work will lead to preparing engineering students with necessary tools and skills required to work in a competitive environment by matching industry expectations.

Methodology

To understand the perception of CSP's by mechanical engineering students and potential employers a non-experimental, descriptive research methodology was used to gather the data for this research. A cross-sectional survey was conducted on two target populations consisting of graduating mechanical engineering students and hiring engineering firms. Rating scale questions based on Likert scale were developed for students. These types of questions are useful for determining the prevalence of an attitude, opinion, knowledge or behavior information on a population at a single point in time. Students were given five choices from strongly disagree to strongly agree options for a set of seven questions. A total of 40 students (70% of graduating class) participated in this survey. Responses from these students were collected and qualitatively analyzed for understanding their perception of CSP. Another set of the data was collected by interviewing hiring managers from industry. Manufacturing industries surveyed for this research included reputed engineering firms that regularly hire engineers for various positions (production, product development and research). A similar survey consisting of seven questions was developed for industry. The questions primarily focused on understanding industry's views about CSP's and their expectations from fresh engineering graduates. A total of 6 manufacturing engineering firms participated in this research. The companies included John Deere, Caterpillar, Bobcat, 3M, SpaceAge Synthetics, and Greenland Composites. All these companies have strong global presence and are heavily involved in manufacturing sector. They regularly hire NDSU mechanical engineering students and also help to review engineering program as advisory board members. These companies also sponsor CSP's with engineering schools and offer internships and cooperative opportunities for engineering students.

Student's perceptions about CSP's

Table 1 summarizes the student response to CSP's evaluation questionnaire. Overall the survey showed students were highly satisfied with the structure of currently offered CSP's by Mechanical Engineering Department. They were excited and hopeful that this experience will help them in obtaining an internship or a new job with reputed engineering firms. Majority of the students agreed that CSP helped them to apply their class room knowledge and laboratory skills into industrial projects. They expressed that CSP's gave them a great opportunity to work in a team and helped them to network with fellow students from other disciplines and industry

experts. They considered these projects as skill building activities that will be useful in their first professional jobs. They also stressed the importance of project planning and communication while working on these projects. Students appreciated the freedom to work independently on the CSP. It gives them flexibility to work on their own schedule without interfering in the regular class schedule.

Table 1. Students Evaluation of CSP's offered by Mechanical Engineering Department

Selected Survey Questions	Rating Score
Satisfaction with current format of CSP's	4.35
Quality of CSP's offered by ME Department	3.85
Application of classroom knowledge in CSP's	4.41
CSP will help in getting internship/job	4.08
CSP assist in engineering skill building activities	4.15
CSP meet employer expectations	3.72
CSP help to prepare for competitive environment	3.95

Number of student participants - 40

Rating Scale - Strongly disagree=1, Disagree=2, Neutral=3, Agree=4, Strongly Agree=5

The survey also found some weaknesses in the current CSP's. Students hoped the project selection pool was much larger and covered wider manufacturing sector. They would like to work on a wide variety of real life projects where multidisciplinary teams are involved. They expected larger participation from industry and manufacturing sector in offering CSP's to the ME students. Students liked to spend more time on design aspect as compared to project planning, budgeting, report writing and presenting to audience. It was also noted that variation in the complexity of these projects can take significant amount of student time and can lead to unfair grading. The degree to which mentor get involved in these projects was also a concern. Students hoped mentors could spend more time in the beginning of CSP so they can quickly move to design phase.

Although students found that CSP experience helped them to become well rounded engineers to compete in a tough job market still there are certain areas that can be improved to meet employer expectations.

Industry's Perception about CSP's

It was found that industry is well aware of CSP's that are offered to engineering students. All the participating industries and engineering firms strongly supported inclusion of CSP in the engineering curriculum. Industry believes this experience helps students to build necessary skills needed for entry level jobs and internships. According to several hiring managers CSP provide first-hand experience in project planning, management, budget planning, and understanding engineering economics. The small CSP projects expose them to a business like environment where they can experience how rational decision making process is important for project success. They can visualize various types of problems, risks associated with engineering projects. CSP's also teach them time and budget management skills. System design process exposes them to understand multiple solutions and their constraints. All these activities help them to think critically and understand time value of money and human resources. Table 2 summarizes the

overall response of the survey conducted to understand the importance and role of CSP in the interview and hiring process of six different manufacturing companies. The engineering hiring managers were interviewed to understand their views about CSP and the quality of market ready fresh engineering graduates.

Table 2. Overall perception of CSP's by various Industries

Selected Survey Questions	Rating Score
Industry familiar with CSP's in engineering curriculum	4.8
CSP's training important to industry	4.3
Quality of CSP's conducted by students	3.5
CSP's help student to improve engineering skills	4.5
Role of CSP's in the internship/interview process	3.8
CSP meet employer expectations	3.2
Current CSP structure sufficient	3.8

Number of industries participated in this survey - 6

Rating Scale - Strongly disagree=1, Disagree=2, Neutral=3, Agree=4, Strongly Agree=5

All the companies interviewed believed that CSP's play a significant role in the engineering education especially preparing the students to obtain internships and entry level jobs. The current format of CSP has some inherent flaws which restricts the students to meet the employer expectations. One of the major weaknesses discussed by several industries is lack of project management skills by graduating engineers. A few employers also mentioned that students tend to skip basic engineering calculations. The project design and alternatives should be engineering calculation driven not solely design. Students should take advantage of non-destructive simulation based design concept strategies. A lot of fresh graduates are deficient in understanding engineering economic and financial reports. CSP may not play a major role in landing them a good job but it can play a significant role in earning them internships with manufacturing industries. The current format of CSP needs to be strengthened in certain areas such as project management, budget development, project feasibility, and design capability. The type of CSP's offered to students should be of practical value where they can learn and improve their engineering skills by focusing on hands on activities. Industries were also wary about engineering student's communication and writing skills. They advised that students should mention CSP on their resume and discuss in detail with hiring managers. They also wanted students to strengthen their knowledge in emerging fields such energy utilization, mechatronics, simulation and polymer engineering. Majority of the participants in this survey were very optimistic that a few modifications in CSP structure can help to meet their expectations.

Recommendations for strengthening CSP

The outcome of this study will help to improve the overall effectiveness of CSP training in the engineering curriculum. The weaknesses identified by students and hiring managers will help to strengthen the existing CSP format. Local industries will be encouraged to sponsor real life projects where students can work and interact with faculty member and industry partner at the same time. This activity will help to bridge industry needs and student training to produce well rounded engineers. Project planning component of CSP will be strengthened to ensure students understand the importance of time value and risk management. Students will be also encouraged

to use engineering calculations and simulation software to design and analyze their systems. CSP's related to emerging technologies will be encouraged from industry and research faculty. The importance of CSP in engineering education, training and job search will be incorporated in the CSP course outline. It is expected that this work will help to better prepare our engineering students for industry careers and create an effective environment between academia and industry requirements. Finally this task will also help to reduce CSP perception gap between students and industry.

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