Capstone Project Mentorship

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Mentorship by a corporate liaison (corporate mentor) and a faculty coach (technical mentor) are often offered to students, as they fulfil the requirements of sponsored senior design projects. The mentor's background (functional versus project-based) and capability (technical area of expertise) play an important role in the type of mentorship offered to the students. Some factors that influence the type of mentorship offered while serving as corporate mentor or technical mentor to capstone teams are presented in this paper. Being aware of these factors can help students appreciate their mentors and avoid generalizing the senior design experience to working in industry as a whole.

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Introduction

Capstone (Senior Design) projects offer project-based work experience to graduating students who may seek gainful employment at the conclusion of their senior year. The projects are offered in engineering programs to give graduating students an opportunity to practice design in a way that parallels what will be encountered in professional practice[1]. The project requirements can be specified by a sponsor in order to benefit the sponsor in their business. Such projects can prepare students for their first job in engineering after graduation while also providing industry with tangible benefits[2]. In that context, a successful senior design project is one that produces experienced graduating students who are one-step-closer to competitively gaining employment. The project also achieves the required performance and satisfies tangible demands set forth by the sponsor. When asked, students express that they find it important to work on projects that offer experience in a particular field of interest with an organization that can offer employment opportunities[3]. The benefits of the capstone projects to academia and to industry are well established, regardless of the discipline.

The projects sought for senior design can be new product development, manufacturing process equipment, or system integration from external (e.g., corporate) or internal (e.g., faculty) sponsors[4]. These projects span over two semesters in many colleges where a team of students design and fabricate while they are mentored by a corporate liaison (or corporate mentor) and a faculty coach (or technical mentor) throughout the duration of the project.

The students, working on a senior design project, are completing their senior year and their technical knowledge of fundamental engineering concepts is fresh in their minds because of all the classes they recently took. However, mentorship from the corporate sponsor and the faculty advisor is essential for the students to gain confidence in using the knowledge they have gained as they learn project management and technical tools that are necessary to keep their project positively progressing.

Leadership, from the corporate and technical mentors, is supportive and sometimes necessary to pull a project from start to finish. A study[5,6] describes how faculty advisors and graduate teaching assistants enact leadership as an influence process within design teams. The authors conclude that advisors and teaching assistants who are active in the team and offer effective leadership may enhance the extra effort and satisfaction of their teams.

The purpose of this paper is to present some factors that may influence the type of mentorship the corporate liaison (corporate mentor) and the faculty coach (technical mentor) provide to the capstone student teams.

Corporate Liaison / Corporate Mentor

The corporate liaison is typically a professional, employed by an organization, with a desire or a need to develop a new product, manufacture process equipment, or perform system integration operations. Organizations operate in different manners as they execute projects according to the Project Management Body of Knowledge (PMBOK[7]). Specifically, organizations can be functional, project based, or matrix.

Functional organizations include departmental managers, where each department (e.g., engineering, manufacturing, research & development, marketing, etc.) is managed separately. As new contracts are introduced into the organization, they are assigned to a project coordinator (or project expediter) who tracks projects but has no authority to make decisions or spend money. The

coordinator works with functional managers who assign tasks to employees in their department. The work is tracked by the project coordinator who provides updates to the functional managers as the work is being done.

Functional organizations allow employees to gain a deep vertical knowledge of their specialized areas. However, they may limit opportunities for interaction with customers and project stakeholders who may have difficulty expressing additional needs for clarifications or changes to the project. Additionally, the functional managers may unknowingly overwork their best resources who have the deepest expertise and knowledge instead of balancing the workload[8].

A liaison engineer, in a functional organization, working with capstone design team can report to an engineering manager, manufacturing plant manager, research and development manager, or other functional manager. The mentorship offered by this liaison engineer can be highly focused on the specific area of expertise of the liaison while the capstone project team may need support in multiple areas.

Project-based organizations, in contrast to functional organizations, rely on project managers who form project teams with no functional managers[7,8]. A project team is directly responsible for their project, under the leadership of the project manager who has authority over the budget, scope, and time. Project-based organizations foster collocation of resources to multiple projects while improving focus on driving each project to completion. Customers and project stakeholders interact with the project manager as the project team can make clarifications, assess opportunities, and make scope changes efficiently. Project schedules include the allocation of resources over the duration of the project to keep the project moving while balancing the workloads. When the project is complete, the team is dismantled as other teams are formed.

The liaison, working with a capstone design team, may not have expertise in the technical area of the project. Instead, this liaison is typically focused on the "golden triangle" of cost, time, and scope. The liaison mentors the team and guides to success by leveraging available resources and helping the team find expertise within the corporation or its subcontractors as the capstone project progresses according to a clear schedule.

Between the two extremes (functional versus project management), matrix organizations can operate in a blend of functional and project-based manner. The blend can be close to functional (weak matrix), balanced between the two (balanced matrix), or close to project management (strong matrix)[7]. Furthermore, a company can successfully evolve between a functional organization and a project-based organization while experiencing changes in its management over time[9].

The immediate impact of the organization type on mentorship can be described by the following examples. While employed within a research group in a functional organization, the corporate mentor for a capstone project expects to see focus on research and drives the students in that direction where a patentable product[10] is being tested. The senior design team, in this case is to design and build a test fixture for this particular product and test the product against prior art. The desired report at the end of the project, in this case, would be a research report. After all, the Liaison may be in a position directly below the manager of research and would only be proud to deliver a solid research report.

Similarly, focus would be on engineering drawings if the liaison belongs to an engineering group in a functional organization.

In the same manner, the focus would be on the cost, schedule, and scope if the liaison were part of a project-based organization.

The given examples illustrate the influence of the sponsor's organization on the way the corporate liaison functions directly affects the performance of the team. Making the students aware of this, can help the students understand and appreciate the decisions and the drive of the corporate mentor.

It is also important to note that the corporate mentor often captures an opportunity for personal growth from the two-semester-long journey. A seasoned research engineer from a functional organization with deep knowledge of their research area realizes quickly that senior-level students offer breadth and new points of view. Similarly, the senior mentor who is employed in the engineering group of a functional organization can see products come to life quickly by students who are quite capable of creating 3D models for 3D printing. The liaison from a project-based corporation can be impressed by the ability of students to use portable scheduling and project management tools[11] that are quite useful to take back to the corporation. Here, the student team offers a fresh point of view to design problems and can refresh the spirits of a senior employee in a corporation

Faculty Coach / Technical Mentor

Students, after several years in college, are comfortable seeking technical knowledge from their faculty. The senior design team expects the faculty to teach and know all the answers. However, working on capstone projects can be a very humbling experience when the project is not in the professor's direct area of expertise and some faculty do not wish to work outside their area[4]. For example, from personal experience while mentoring teams[9], a faculty member with expertise in thermal fluids sciences and heavy manufacturing can be quite uncomfortable while working with students and corporate mentors on projects related to food processing,

beverage handling, acoustics, telecommunications, or civil engineering. A mechanical engineering professor can be also be sidetracked while mentoring a team that takes a very comfortable cooling or dehumidification project into applications of compact thermoelectric devices[9].

While working on projects outside the professor's area of expertise can be humbling and uncomfortable, the exposure to new areas under a strict capstone project timeline can bring new opportunities for research and teaching. However, passive and ineffective leadership from the faculty can also result in this situation and can hinder the team's motivation to put extra effort into the project[5,6].

In this case, the faculty coach cannot offer expertise and direct technical guidance but can continue to help the students as they follow the engineering design process[12] and progress through the capstone course. The faculty coach can also provide guidance to help the students listen and learn from the corporate mentor or others who may have the required knowledge and experience.

Further, the tools described in Juran's quality planning and analysis[13], can be very effective in providing students with tools such as Pareto's diagram for troubleshooting defect types and Ishikawa's fishbone cause and effect diagram. These tools are application independent and can apply with the same relevance to a wide range of applications (e.g., mass manufacturing of automobiles versus the restaurant business).

As an alternate example, also from personal experience[9], while mentoring teams, projects can be in the professor's area of expertise. In this case, the faculty coach must practice restraint from making the project their own. Faculty must serve as an advising resource for the team with no intellectual property development by the faculty. The ideation and convergence into the final solution should come from the students and the corporate mentor.

Conclusions

Senior design projects benefit academia and industry as documented in the literature. They typically require a team of senior-level students, a corporate liaison (corporate mentor), and the faculty coach (technical mentor). The type of mentorship can be influenced by the type of organization sponsoring the project (functional versus project-based) and the technical area of expertise of the mentors. Mentorship offers invaluable benefits to students and to the mentors as they work with the students. During the course of one senior design project, a team receives one type of mentorship based on the mentor's background and capability. Students and faculty ought to be aware of the type of mentor supporting the students to avoid generalizing the senior design experience to industry as a whole.

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