

2006-2605: DETERMINING HOW TO TEACH PROJECT MANAGEMENT CONCEPTS TO ENGINEERS

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Determining How to Teach Project Management Concepts to Engineers

Abstract

Project management is becoming a crucial skill in today's work environment. Practicing engineers learned technical concepts in their university studies, but few actually learned project management concepts. These "soft skills" are often overlooked because they are not mandated by accreditation boards – yet. This paper proposes several options for including project management concepts in a university curriculum without sacrificing the time spent on technical concepts.

Introduction

In today's competitive business environment, engineers cannot afford to be pure engineers. In the last decade, many companies have reduced the numbers and levels of management positions and given more decision-making authority to teams at lower levels. Many engineers are now either faced with management responsibilities at their current positions, or promoted to higher positions¹. Therefore, they need to have Project Management (PM) skills to manage various aspects of a project-driven technological organization combining engineering problems, human factors, and financial issues and to work in a cross-functional team either as a manager or as a member of the team.

A recent survey included more than 100 senior-level PM practitioners and 97% of the respondents said PM adds value to their organizations². Consequently, to be successful in this work environment, it is crucial for engineers to have some level of PM knowledge. Companies would prefer that engineers gain this PM knowledge BEFORE they join the workforce. The big question is: what are universities doing today to introduce tomorrow's employees to PM concepts?

Although many universities include a few very basic PM concepts spread about in their curriculum, most universities do not provide detailed PM instruction³. Why not? After all, many companies are expecting new graduates to be productive on their first day of work, and a solid understanding of PM concepts helps these new employees to be more productive team members.

The problem lies in competing goals of a university, a discipline prerequisite knowledge, and the national engineering accreditation organizations. There are only so many credit hours in a typical Bachelors of Science curriculum.

- Most universities want to ensure that a graduate has a broad knowledge of the arts and sciences. To attain this goal, the universities require that students have a minimum number of hours of English, communications, humanities and social science, as well as science. Engineers typically do not have difficulty addressing the science requirements. However, these arts course requirements can account for 20-30% of a student's credit hours. Few schools consider project management courses a social science course.

- An engineering department will identify a technical curriculum for students to follow. Courses in this curriculum often require that students take many courses from a department that is not their primary discipline. For example, Electrical Engineering students must often take 18 hours of math, 8 hours of chemistry and 12 hours of physics in order to prepare them for their major coursework.
- National accreditation boards will assess a program and grant accreditation if the engineering department is correctly preparing students for employment in their technical field. Therefore, engineering courses are pressed to ensure the appropriate topics are covered in the remaining course hours. This leaves little time in the curriculum to cover non-discipline topics.

Designing an Approach

While there are many potential solutions, two possible solutions offer the best chance of buy-in, and thus success, in the University environment. These solutions require involvement of local companies, particularly because universities are historically not known for their PM skills and efforts.

The first solution is for a university to offer a generic PM course, and allow it to be used by students for the university's general education requirements. A course in PM could easily cover the types of knowledge learned in general education courses; after all, topics like English, communications, and social science are core components of the Project Management Institute's (PMI) Project Management Body of Knowledge (PMBOK)^{4,5}. The advantage of this approach is that many university students could become familiar with PM concepts, even beyond the engineering students targeted with this approach. Some disadvantages are that this course would only offer about 45 hours of lecture/class interaction (probably too little to be fully effective), would have to spend time to address core skills like report writing and communications, and would typically be taken by underclassmen due to curriculum constraints. All of these disadvantages point to a class that, while providing a student with a good foundation for PM concepts, might be too general and early for students to really appreciate the value of PM in the workplace.

A second solution is for a department or engineering college to integrate PM concepts into their curriculum, not as an individual course, but as many components that appear in many courses. This is a much more easily implemented solution because engineering programs already have courses in place where they can (and often do) introduce PM concepts. For example, at the author's university, each engineering student will take the following courses during their college career:

- Fall, Freshman year, Introduction to Engineering
- Spring, Freshman year: Introduction to their discipline (i.e. Electrical Engineering)
- Fall, Junior year: Professional Development
- Fall, Senior year: Senior Design (capstone project): project development and definition
- Spring, Senior year: Senior Design (capstone project): project implementation

Many other universities have the same types of courses. However, while many programs do a good job introducing students to some semblance of PM concepts, most do not coordinate a set of "modules" based on the PMI PMBOK. For universities to correctly prepare students, they

must ensure that the PM knowledge presented is prepared by experienced PM faculty, preferably those with the PMI Project Management Professional (PMP) certification. Experience has shown that there are few PMPs in academia.

Companies can help universities with this subject matter. However, a single company should probably not be the primary source of PM curricular material. To make the PM knowledge presented more general yet applicable, local PMI chapters could coordinate the core discipline materials, and the companies can assist by talking about their own implementations and present case studies. Local PMI chapters should collaborate with local universities to establish ties and develop modules. There are several ways a company can help:

1. Corporate management, lead by a company's Project Office, will need to convince university administration of the need for teaching project management skills in universities. Executives can talk with university presidents/provosts, college deans, department chairpersons, and even career center counselors.
2. Corporate Project Offices should, perhaps through their local PMI chapter, assist in curriculum development or assessment.
3. Companies can provide financial assistance to faculty in the form of summer grants to help develop curriculum faster and introduce PM concepts in the classroom quickly.
4. Companies can even offer summer employment to faculty who will be teaching PM modules. This immersion in a Project Office would provide faculty the hands-on experiences in PM they often lack.

An Example Approach

In a senior design course, students create teams of two to four participants, identify a problem to solve or product to create, and spend one or two semesters completing their work. Students attempt to demonstrate their technical and design skills by completing a project on time and with full functionality. Unfortunately, some students do not complete the full functionality promised in their original requirements documents or "project contract". Some do not even complete working systems, only working subsystems. A survey was conducted of department faculty at the author's institution on senior design project performance. The goal of this survey was to document the level of PM skills of the students, by gathering inputs from educators who guide and grade senior design projects⁶.

While many universities include PM concepts in their curriculum³, guidelines for faculty to follow are sparse. Although the PMBOK and PMI certification is valuable in industry, it is too extensive to cover completely in a university curriculum centered on technical skills. It is, however, an excellent basis that educators can draw from and incorporate into existing courses. In the Project Management Body of Knowledge, there are nine knowledge areas⁴:

- **Project Integration Management (1)**
- **Project Scope Management (4)**
- **Project Time Management (4)**
- Project Cost Management
- Project Quality Management

- Project Human Resource Management
- **Project Communications Management (1)**
- **Project Risk Management (4)**
- Project Procurement Management

The bolded knowledge areas above represent those that should be addressed in detail in a senior design course. Further, the numbers in the lines represent the number of processes in that knowledge area that should be specifically taught in the course. These processes have been identified as important to PM by the author, a certified PMP, and are also consistent with the survey results. The survey revealed that students have problems with project planning (setting clear goals, schedule and resources), communication, numerous midcourse changes, and risk management. Appropriate project integration, scope, time, communications, and risk management knowledge will teach them how to deal with these problems to achieve much better outcomes in their senior design projects, as well as in the workforce.

Project Management Modules

These fourteen processes can be grouped into three distinct pedagogical modules and taught over the course of a minimum of three weeks, with at least three hours of classroom instruction for each module. It would be expected that each module would include lecture with hands-on, in-class exercises and well as assigned and graded homework. The senior design students could learn from these exercises and apply the knowledge to their own projects. These areas have been suggested in a paper by Conrad and Sireli⁶.

Project Scope and Work Breakdown Structure Identification: Often a senior design project has an industry or academic sponsor. In this module the students will learn how to identify the scope (expected deliverables and functionality) of their project and develop a scope statement that satisfies their sponsor. Students will also learn how to verify and control changes of the scope. Another important concept taught in this module is creating a work breakdown structure (WBS). A WBS is a deliverable-oriented grouping of project components that organizes and defines the total scope of the project^{4,5}. A WBS is considered one of the most important documents of project planning - it is used in most of the other project processes. Students will practice creating a WBS all the way down to the work package level.

Project Time and Integration Management: Once the project scope and WBS is developed, project activities are planned. In this module students will learn how to convert their WBS to specific identifiable tasks, and then sequence these tasks to create a project plan that can be followed during project execution. This module will also include an introduction to PM tools like GANNT charts and the application MS Project.

Project Risk Management and Reporting: Risk management is a concept that receives little attention in the academic world, but is an important component of large project implementations. Students are not prepared to address problems that arise in their own senior design projects, and thus are rarely able to respond to risks in their first employment position. This important topic is taught in the third module, and includes planning, identifying, controlling, and mitigating risks in

a project. Students will also learn risk assessment and progress reporting during project execution.

A Specific Example - UNC Charlotte

The original motivation was a personal observation of the quality (or in some cases, lack of quality) of Senior Design Project deliverables at the University of North Carolina at Charlotte. In order to make a more thorough assessment, a survey was conducted of Electrical and Computer Engineering (ECE) Faculty on senior design project performance⁶. As mentioned earlier, the goal of this survey was to document the level of PM skills of the ECE students, by gathering inputs from educators who guide and grade senior design projects. The survey was intended to document students' PM abilities by investigating the following⁷:

- Technical skills to measure students' ability of implementing basic PM tools and techniques through a project life cycle.
- Socio-cultural skills such as teamwork and communication to manage real-world problems.

The overall performance of the students in meeting expectations was rated between "moderate" and "good," but closer to "moderate." Their project planning abilities (setting clear goals, tasks, schedules, budget, and resources) were also rated in this category. Socio-cultural skills such as leadership and problem solving were additional candidates for improvement. Students were not able to foresee risks and prepare contingency plans accordingly since these skills were rated between "poor" and "moderate."

These results are not surprising, since the two-semester senior design sequence contained no instructional content whatsoever. Those groups that succeeded did so because they learned design and project management skills from their previous industry work experience, or because their faculty advisor served as a project manager of the effort.

The first step to improving the PM skills of graduating seniors at UNC Charlotte is to introduce these skills in the senior design courses. Starting in Fall 2006, the ECE and Mechanical Engineering Departments will closely coordinate their senior design programs, including teaching the same PM lectures/exercises to both groups. The lectures will be organized in the modules described above and will include in-class hands-on exercises in order to reinforce concepts learned. These modules will be created in the summer of 2006 for implementation during the 2006-2007 school year in the department's Senior Design Course with the assistance of the local PMI organization. They will be reviewed within the PMI organization and corporation Project Managers. Some of these modules will be available for examination at the 2006 ASEE Annual Conference.

This effort to improve the senior design experience has been requested by the Engineering Dean and the department chairs, so no implementation barriers are anticipated. We do expect initial student "grumbling", since they will now be required to attend a weekly lecture that previous graduating classes did not have to attend. We expect that the students will eventually realize the lectures and exercises will help them work more productively. We intend to survey faculty

advisors of senior design projects at the end of the first year to assess if the faculty observe a difference in quality of the project deliverables.

Conclusion

University faculty want to provide sound education to students. With the quickly changing employment landscape, this education should include more “soft skills” like PM. With corporate help, local universities can quickly adapt and produce future employees who are more productive and better attuned to industry development environments.

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