Integrating Project Management into the Capstone Senior Design Course

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Abstract

The public and private sectors are demanding entry-level technical personnel that are well schooled in the fundamental principles of their respective engineering and technology disciplines. Both of these groups are placing a premium on graduates who have had significant design experiences and have participated in a team environment. Finally, these potential employers are demanding graduates that have the ability to communicate effectively in both written and verbal formats. These new hires will, in all likelihood, become members of project teams and participate as team members and eventually as project managers. The Electronics and Telecommunications Engineering Technology (EET/TET) Programs at Texas A&M University have established a mandatory technical project management course that is closely linked to its capstone senior design course. With assistance and participation from a number of large and small companies, EET/TET students now learn about the fundamentals of project management while they prepare for entry to their senior design project. The new course provides the opportunity for students to form teams, evaluate potential project opportunities, arrange for faculty and industry support and sponsorship, and prepare the written documentation and technical presentations that culminates in a formal technical proposal. Using the Project Management Institute (PMI) Body of Knowledge, the students plan the work they will accomplish in their capstone senior design course.

I. Introduction

As part of an overall strategic planning function, numerous faculty members of the Electronics and Telecommunications Engineering Technology (EET/TET) Programs at Texas A&M University met with representatives from a wide range of industries during the Spring and Summer 2001 semesters. These meetings were attended by representatives from the semiconductor, semiconductor equipment manufacturing, telecommunications, and instrumentation industries. The overwhelming recommendation from this diverse set of industries was that more emphasis needed to be placed on a systems approach to engineering technology education. With minor exceptions, companies that have a long-term relationship with the EET and TET academic programs are quite satisfied with the technical knowledge, or hard skills, that the graduates have, but they are not pleased with the project management, or soft skills, that they currently possess. In addition, most industries are very interested in forming even closer alliances with the undergraduate students and wish to leverage the internship experience that students normally have just prior to beginning their senior year of classes.

From this input, the EET/TET faculty, with the encouragement and support of many members of its Industry Advisory Committee, set out to integrate project management fundamentals into both educational programs. In the past, EET/TET students were required to complete a three-hour management theory and concepts course offered by the Business Department. It was decided that this course would be replaced with one taught by EET/TET faculty that would teach the basic principles and practices used in the private sector to plan, execute, and control small and large projects alike. The private sector also urged the programs to align its new course content with the Project Management Institute and utilize the Institute's Body of Knowledge as the underlying tenets for the course.

In addition to exposing the students to the discipline and tools of project management, the course needed to serve another, practical purpose that was closely associated with project management. Over the past five years, the capstone senior design course had become more popular in the private sector as a way to leverage the investment the company had made in a student or group of students. Generally, companies wanted to sponsor a senior design project to continue or expand the work that had begun during the internship experience. As these projects have become more complex and demanding, having the student design teams do all the planning, design, implementation, testing, and documentation in a single semester was asking too much of the students for the time and credit that was given for the course. By adding a course in project management fundamentals, the students could focus on the initiation and planning processes of a project in the first course and then execute, control and close the project in the following semester. This two course sequence provided more time to accomplish the project which translated into more successful projects that could encompass more demanding requirements.

During the Summer 2001 semester, EET/TET faculty members visited many different industries and met with their project management staff to determine what the course should include. The course content was then developed and the new project management course was offered in its current form in the Fall 2001 semester. This paper summaries the experiences and lessons learned to this point. During the Spring 2002 semester, the course will be modified to include more material and exercises while the project management course instructor will monitor the impact that project planning and preparation plays on the overall success of thirteen project teams that completed the course in the Fall 2001 semester.

Three faculty members have been significantly involved in this course development activity and have authored this paper. Dr. Joseph Morgan is primarily responsible for the development and delivery of the new course. Dr. Behbood Zoghi is the course instructor for the senior design course and has been actively involved in the course layout, content, and insuring that the requirements of the senior design project course are met. Dr. Jay Porter has been involved in the creation of the course from a faculty sponsor perspective and is currently involved in three of the projects that are being sponsored by the private sector. These three faculty members have brought about a new and exciting course that is

adding value to the industry-sponsored projects being accomplished by the undergraduate students and providing these same students with an understanding and appreciation of tools and processes used by a project managers. Although few entry-level employees will be assigned the responsibilities of a project manager, the graduates of the EET/TET Programs will be much more effective in participating as a productive member of a project team.

II. Goals and Objectives

The overall goal of the EET/TET Programs is to create an integrated two-course sequence at the senior level that allows each student to participate in an open-ended design project performed under sponsorship by some external entity either in the public or private sector. The major objectives of the course were threefold. First, the new project management course would provide students with the fundamental concepts and tools used by practicing project managers in private industry. Using the PMI body of knowledge, students will focus on the initiation and planning of their senior design project in this course so that they are prepared to execute and control the project in the following semester. Second, the course seeks to emphasis the importance of technical communications in both written and oral formats. Beginning with project briefs, the students identify competing design project opportunities. As the individual students interact, design teams are formed and the teams generate white papers to insure they fully understand the objectives and constraints of the potential project sponsor. A formal technical proposal is then generated which contains the detailed planning the team has done in preparation for the project. Finally, the teams create a web presence for their project so that access to pertinent information is available to all stakeholders. The third major objective is to expose the students to important areas of information that are not possible to include in the other technically-oriented coursework. Topics such as business etiquette, resume writing, and compensation packages are included in this new course.

Although the course will continue to evolve, the structure and content appears to meet a very important educational need for the EET/TET students, and there has been increasing interest in using the course content to build both master's degree curricula as well as including some of the topics as a portion of other professional development activities.

III. Content and Focus

The course as offered in the Fall 2001 semester had three primary elements. These elements were integrated over the entire semester to take advantage of as much industry involvement as possible. Many of the topics were presented by practicing project managers or executive-level personnel that employ project management within their companies. The project management fundamentals and tools constituted approximately 50 percent of the course, while technical communications focused on defining

and planning the capstone senior design project used approximately 35 percent of course time, and the final 15 percent was devoted to enhancement activities.

Starting with potential project briefs, the students began their research and identification of possible projects for their senior design course. These one-page documents were generated independently by each student. In completing this task, the students were motivated to interact with faculty, peers, and private industry to look for good ideas and to communicate these ideas in a concise manner to the course instructor and other students in the course. This exercise allowed students to find others that had similar interests to theirs in design-level projects. It also forced the student to effectively communicate the essence of their ideas in a one page summary of all salient project attributes. Many students chose to interview faculty members as a source of project ideas that could be completed as part of an overall funded research project or for which industry funding and sponsorship could be attained. In the future, the EET/TET faculty are planning to share these project briefs with their appropriate private industry contacts to seed and stimulate more interaction and support. The major section of the project brief are as follows:

- Project Name
- Project Description
- Projected Time
- Estimated Costs (Labor and Materials)
- Major Deliverables
- Intended Customer/User
- Overall Value/Benefit
- Critical Issues/Risks
- Decision Window
- Ranking

Over the next part of the semester, students came together to form teams, make final decisions as to what project they would select and to expand their knowledge of the sponsor/advisor needs and expectations for the project. From these interactions, the teams were required to generate a white paper for their project. This document allowed the course instructor, faculty advisor and project sponsor the opportunity to assess the general understanding that the students had concerning the overall project objective and the deliverables that would be generated from the successful completion of the project. The white paper was due at the mid point of the semester and contained the following sections:

- Introduction
- Objective
- Approach
- Work Plan
- Deliverables
- Resource Requirements

The white paper had to be from five to seven pages in length and was used, once reviewed and approved by the three elements (instructor, advisor, and sponsor) as the basis for detailed project planning and generating the formal technical proposal.

Using the white paper and feedback from the three elements, the teams then began their planning process. First the teams were required to develop a detailed work breakdown structure (WBS) that subdivided their project into deliverables, then into work packages, and finally into activities or tasks. This diagram was briefed to the project stakeholders and their inputs were included in the final iteration of the WBS. The goal of generating the structure was to create manageable activities at the lowest level that could be generally assigned to a single individual and required no more than one week of effort. Although not always possible, most of the structures did include that level of detail for most of the activities.

From this point, the teams developed a time orientation as well as interdependency to their activities. Using the Microsoft Project Gantt Chart as the common graphical instrument, the teams develop a planning tool that added structure to their project. As a team, the members agreed to when tasks would need to start and when they would need to be completed. In addition they estimated the amount of effort and assigned responsibility for each task that had been defined for the project. From this process, the teams were able to gain consensus as to the man hours that would be allocated to each task and from that, a workload leveling process was performed to insure all team members contributed equally to the overall project success. The information extracted from the Gantt Chart and workload leveling process then was used to develop a cost estimate for the project. Costing included such categories as Direct Labor, Other Direct Costs, Indirect Costs, and Profit. These planning processes resulted in the information needed to produced a comprehensive formal proposal which was submitted, reviewed and accepted by the both the project management course instructor, the senior design course instructor, the faculty advisor, and project sponsor. This document is now an official requirement for students to be registered in the capstone senior design course in their final academic semester. Each technical proposal included the following sections

- Introduction
- Project Scope
- Statement of Work
- Risk Assessment
- Team Organization and Qualifications
- Project Costs
- Appendices (as appropriate)

IV. Project Management Knowledge Areas

Of the nine project management knowledge areas defined in the PMI Body of Knowledge[1], two of these were selected to be highlighted in the project management course. These were personality trait assessment and analysis, which is part of human resource management, and risk management. The students had the opportunity to learn from experts in the field about the importance of these factors to successful project management.

The EET/TET Programs are fortunate to be part of Texas A&M University where significant expertise is available in a wide range of subject areas. This is especially true in the area of group dynamics and personality assessment. Working with faculty/researchers in the Psychology Department, the project management students learned of new assessment tools being used in the private sector for various purposes that range from hiring and placement to building strategic teams that are charged with major development projects. This knowledge area was first suggested by members of the EET/TET faculty, but received very positive endorsement from many representatives in the private sector. This area was so popular, that not only did the students in the course agree to complete the assessment instrument, but the EET/TET faculty also volunteered to be evaluated.

The short form of the Big Five Personality Assessment Tool[2] was used to gain insight into the characteristics of the students in the project management course. This instrument includes 44 questions that provide an assessment of the individual in five areas: Extravert, Agreeableness, Conscientiousness, Openness, and Neuroticism.
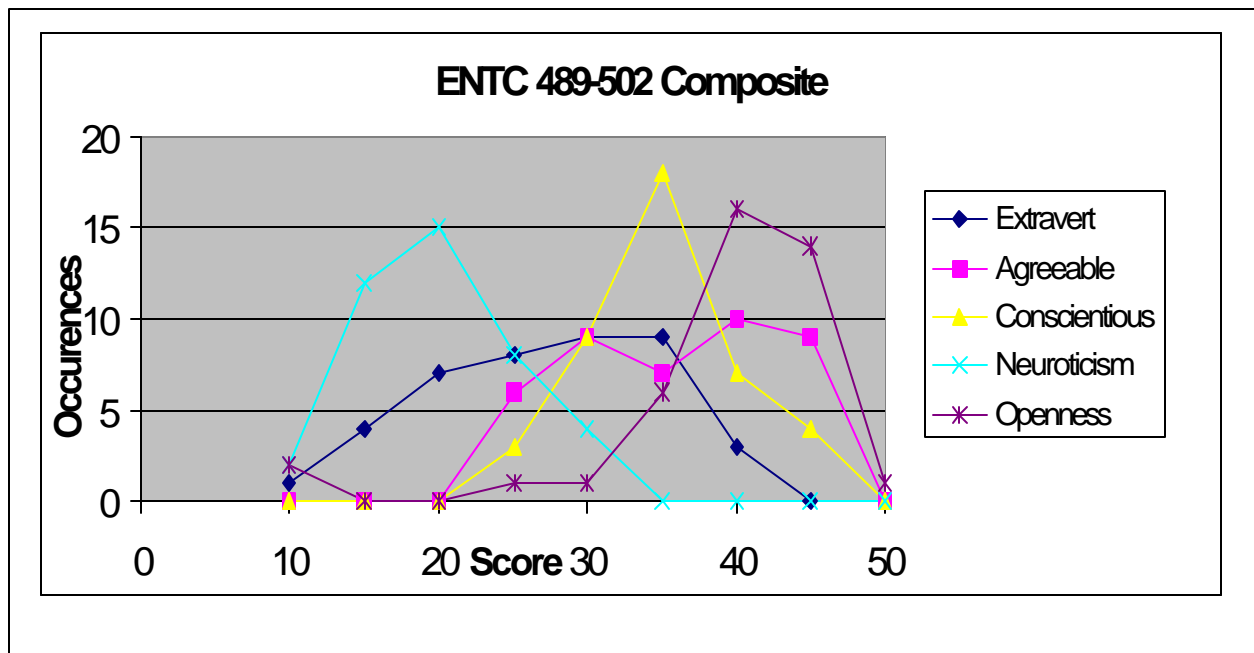
Of these, the last provided the most concern to the students. Neuroticism refers to one's ability to cope with a stressful situation, and also their relative emotional level when compared to others. A higher value in this area indicates a person is more likely to become stressed or generally have a higher anxiety level when pressure is increased, such as when a deadline is rapidly approaching. A lower rating implies a person is generally very stable and quite unflappable in the face of adversity but it is meant to indicate the tendency to change direction or focus. The aggregate results for this survey appear in the following figure and were provided to the students in addition to their own assessment scores. It would appear as a group, the project management course was made up of students that were extremely open and very conscientious. There seem to be a wide distribution of personalities from mildly extraverted to somewhat introverted. The group tended to be fairly agreeable and demonstrated little neuroticism.

Each student was able to assess their evaluations with the composite values of approximately 40 other individuals who were very comparable. Having this information provides each student a basis on which to better understand how they will perform in a team environment and what part they will play in the group dynamics. They also learned there are no wrong answers or bad personality types, but rather how group dynamics can be affected by the personalities of the individuals in the group.

Working with the Psychology faculty members, two student teams extended this exercise as special project. Each group agreed to participate in much more extensive personality assessment and to use the results to better understand what type of person they were. The teams then compiled all of the individual assessments, and with the assistance of the Psychology Department, they predicted the group dynamics that they would experience in the following semester while actually performing their design project. The two teams have agreed to meet every five weeks during the Spring 2002 semester to discuss the merits of their initial reports and predictions in context with how they are actually functioning in a team environment.

The second knowledge area that was emphasized in the project management course was risk. This is one of the most exciting and developing areas within the project management discipline. The EET/TET Programs were fortunate to gain the interest and involvement of the internal project management training staff of the USAA Corporation to work with the Programs in preparing and delivering this block of material. Using a two-way interactive video classroom environment, instructors at the USAA Headquarters facility located in San Antonio delivered the lecture[3] on risk management including identification, assessment, response and control of this critical factor. Each team then developed their project-specific risk factors that included a plan to eliminate, transfer, or mitigate each risk that could negatively impact their project success.

V. Summary

The first offering of the project management course was well received by the students and was approved for continued development by the permanent faculty members of the EET/TET Programs. Those individuals from the private sector and in other departments and organizations within Texas A&M University that participated in the delivery of the course material all had positive comments and volunteered to continue in developing and expanding the course. There has been interest in creating a similar course at the masters level that would encompass all five process groups and nine knowledge areas defined within the PMI body of knowledge. Other instructors who have incorporated team projects in their courses are interested in integrating portions of the project management discipline to more effectively manage their projects. Finally, a representative from the Houston branch of the Project Management Institute has contacted the EET/TET Programs about forming a PMI student chapter at Texas A&M University.

Overall the development of the project management course and its linking to the capstone senior design course has been a successful work in progress. Continuing to expand and enhance the course content and adding more project management principles and processes to the senior design course will create an educational experience for the students of the Electronics and Telecommunications Engineering Technologies Programs that is in tune with industry's needs and allow graduates of the programs to more effectively hit the ground running as a productive member of a technical team.

Bibliography
1. A Guide to the Project Management Body of Knowledge – PMBOK Guide 2000 Edition, (ISBN: 1-880410-23-0).
2. McCrae, R. R., & Oliver, J. (1992). "An introduction to the five-factor model and its applications." Journal of Personality, 60 (2), 175-215.
3. Fantasia, M. Risk Planning: How to make it easier, Learning Systems, USAA October 23, 2001.

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