

AC 2009-263: EXPERIENCES IN TRANSFORMING AN ENGINEERING TECHNOLOGY CAPSTONE SENIOR DESIGN COURSE

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Experiences in Transforming an Engineering Technology Capstone Senior Design Course

Abstract

Until recently, the Electrical Engineering Technology (EET) program at Georgia Southern University (GSU) offered a comprehensive engineering design course (TEET4630) which was a three-credit single semester course that all EET majors were required to take as a capstone course for the EET program. The main goal of the comprehensive course was for the students to apply their theoretical and practical knowledge for the solution of an actual engineering problem. However, although the department has offered this course for many years and students have developed successful and interesting projects, in its original format, the capstone course was too short and did not afford the students time to truly demonstrate their capabilities.

Also, in order for the EET program to fulfill more strongly the ABET outcomes related to demonstrate that students are able to function on multi-disciplinary teams (outcome d), that they show a strong ability to identify, formulate, and solve engineering problems (outcome e) and are able to understand professional and ethical responsibility (outcome f). Based on these goals, the EET faculty and its Industrial Advisory Board (IAB) agreed to modify and expand the EET Senior Project Course into two courses. TEET4610 is a 1-credit course offered in the fall semester, and a TEET4620 is a 2-credits course offered in the spring. Prerequisites for taking these courses were also expanded to include Microcontrollers and advanced Electronics courses that are needed for successful completion of the capstone project.

This paper describes the faculty effort required to make the appropriate changes in preparation for the new format of this course, the particulars of the implementation, how the course evolved and the improvement in student performances are described. We also present the methods, mechanisms, and lessons learned during the process and how they can be helpful to others contemplating a similar course, or those anticipating a revision to an existing engineering technology program.

Introduction

Most four-year engineering technology programs culminate in a capstone senior design course or workshop. The objective of the capstone design course is for the students to demonstrate their understanding and application of the theoretical concepts they have learned throughout their degree program. Though the goal of these courses is the same, the extent and quality of the end result varies substantially from different schools or programs. Some senior project courses involve only some kind of design, simulation or research in a particular topic, while others involve the design and development of an actual working prototype¹.

Until recently, the EET Program at GSU used a single-semester capstone course model. In that course, the entire class met twice a week in a one-hour seminar two hour-lab format, so that the teams made questions and report progress in the one-hour seminar and work on their projects in the lab. All the projects proposed and implemented in the old format were developed individually. This methodology produced varied results with a few excellent students completing their projects while most students achieved varying degrees of success (or failure) this was due mainly to the short time available in a single semester that students had available for implementing their projects.

In our departmental meetings we began to stress the need and importance of project management tools and techniques for our EET graduates. Also, in meetings with our IAB, some members communicated the growing need for new graduates to have these skill sets in entry-level employees and wanted them to have the educational experience to work in a real-world team projects. Based on these needs, the EET faculty redefined a new senior project course sequence that could incorporate the recommendations of our industrial board while also reducing the negative aspects of the current single capstone course^{2,3}.

Over the last year, a new approach to managing the capstone design sequence has been developed. The sequence is now divided into two courses.

The new two-course sequence now requires the students to:

- Find or propose a project
- Create a group of technical assistance advisors that may include internal and external faculty, agencies sponsorships and industrial advisors.
- Create a student project team.
- Write an initial project proposal that has to be approved by the faculty advisor
- Develop a conceptual design, a project management plan, and to write a formal project proposal
- Take the design from paper to an implemented prototype product.
- Present the final prototype in a professional presentation and demonstration.

The first semester of the senior design course has four primary objectives.

- To learn the fundamentals of an engineering project management and development such as project research.
- To write a project proposal, identify major task involved, task management and scheduling, cost management, etc.
- To identify a technical assistance group that will be available as a resource as they implement their project.
- To research all information needed to design and implement their project.

The second semester of the senior design course has three primary objectives.

- To implement and develop all the hardware and/or software related to their project.
- To write a professional project report, with detail information about the implementation of the project.
- To do an oral presentation in front of all EET faculty and industrial partners.

Using weekly, meetings the students report progress through the presentation of deliverables, discussion of issues and concerns, and creation of action items. The results of this new process have been excellent. Through the continued development, review, and improvement process, the new senior design project course sequence is exceeding initial expectations. Faculty is noticing a better investment of the students in the projects and is detecting a higher level of satisfaction with the course. Industrial partners have also mentioned their satisfaction with the projects developed by the students. The quality and success of senior design projects has increased dramatically. The results of most of the projects are now better prototypes. Upon completion of the first course, the students have to write a formal project report and to do an oral presentation. The report and presentations are evaluated by most of the EET faculty and any industrial sponsor related to the projects that focus on deliverables and the quality of the final product.

The new format has increased the level of student achievement in the capstone process and their final project implementation is now typically more professionally manufactured, so that they gain professional experience that could lead to better job or to the development of a commercial product.

Current Course Structure

As discussed previously, the new capstone experience is now a two course sequence where the first course teaches the students the basics of technical project management⁴ and also allows them to plan their project. In the second course, the student teams work to implement their design and develop a working prototype. With the students now having two semesters to complete their projects, the results have been very good, with many groups developing excellent projects. In the following sections, we give a more detailed explanation of the senior design process.

First Semester – Project Management

The overall goal of the TEET4610- EET Senior Design I course is to provide students with an understanding and appreciation of working effectively in a team environment to accomplish an open-ended design project. By effectively planning and communicating the scope of their project, a realistic assessment of project time and costs can be made. Successful completion of this course provides the student with the tools and knowledge necessary to plan, conduct, manage, and document a valuable and beneficial senior design project⁵.

In parallel with the planning process of their own project TEET4610 students acquire basic knowledge of project management tools and techniques. All of these tools are used in the planning and communications of the project's scope, time and costs. In addition, the teams will start some initial theoretical work related to their projects that could include design, simulations or programs that are needed for the implementation of their project.

During the first week of the course, the students are expected to form their design team (typically 2-4 students) and begin brainstorming ideas. Because students already know each other, team formation is typically easy to do. In fact, many students have chosen their teams before starting senior projects. Once the team is formed, the students have a period of two weeks to identify possible project ideas. To help, potential sponsors including faculty and industry members are invited in during the second week to make idea presentations.

Once the team has selected one of their ideas for implementation, they must write a project proposal to the course faculty advisor technical advisor. It is the team's responsibility to convince the advisor of the idea's merit, its feasibility, and of their ability to complete the project on time.

From the time the student teams selected an idea for implementation, they have four weeks to further develop the idea into a formal project proposal that should be approved by the EET department. The writing of the project proposal motivates the students to look at their idea in more detail. Specifically, they have to define the objectives of their project, create a work plan, do an assessment of the project's technical merit, determine resource needs and cost, and detail their final products.

After the project proposal has been approved, the teams must begin to produce intermediate products related to their projects which could include:

- Block Diagram of the System - Identifying main modules needed to implement the system
- Circuit Schematics – Detailed technical engineering schematics of all fabricated circuits.
- Software Flow Diagrams – Document that explains the functional operation of the software.
- Test Plan – Document with detailed test procedures for the entire system and its subsystems.
- Test Results – Document containing the results gathered during the procedures found in the test plan.
- System Specifications – Document listing the physical and electric specifications of each device in the system.

Finally, by Week 15 the students must submit a final technical report that demonstrates their advances the implementation of their project, a detailed work plan, a dated list of intermediate products, and do an oral presentation of their project in front of all EET faculty members.

Second Semester – Senior Design Project Implementation

TEET4620- EET Senior Design II is the second course in the two-course sequence. Teams of students that have successfully completed the TEET4610 course requirements will move on to this course the following semester. TEET4610 is focused on the planning of the project, TEET4620 focuses the team's attention on the execution and control of their proposed project. Overall, the course has the following goals and tasks:

- Each team member must be equally productive on the project. In the formal proposal, the team outlined the project down to the individual tasks and assigned lead responsibility for each of these work packages to a particular team member.
- Team should coordinate and conduct project status review meeting each week with the project advisor.
- Provide a formal mid-term oral presentation on the overall advances of their project.
- Deliver a complete final report that includes technical documentation such as: Initial Project proposal, Project Report and if needed a user manual.
- Conduct a final project presentation.
- Demonstrate project's success through project demonstration in front of all faculty members in the EET program.

During the first week of TEET4620 (Week 16), each team must schedule a regular weekly meeting with the faculty advisor to accommodate the schedules of everyone involved. During these thirty minute meetings the teams present their weekly accomplishments, demonstrate advances, and request assistance from the advisor.

Another very important aspect of the new capstone sequence is the concept of scheduling. As mentioned previously, the students must create a list of partial products. These items are generally interfaces, schematics, circuits, PC boards, etc. and are used to show tangible evidence of progress by the team.

The student team must date each partial product as part of their technical proposal. This process has made a huge difference in how well the students stay on schedule. Having strict dates to finish specific items typically gives them a reason to make continued progress and has reduced the problem of student teams that procrastinate until the last few weeks of the semester.

During the seventh week of the semester (Week 23), all teams must present an oral presentation of their advances. At the oral presentations all teams are present and thus are able to assess their accomplishments in terms of what other teams have accomplished. This is again a motivating factor for most teams in that they work hard to stay ahead of the other groups.

Their capstone experience culminates with a formal oral presentation and project demonstration. It is during this demonstration that all of the members of the team must show a technical understanding of their project and must demonstrate their responsibilities in the project and the operation of the working prototype. Also, each member of the student team is individually evaluated.

Conclusion

The new two-semester senior project sequence has now been offered for one year. Over that time, a process of review and continuous improvement has been used and the new sequence is now consistently producing quality and successful senior projects. In fact, the last two semesters have generated several projects that could easily serve as beta prototypes for commercial products. Many factors can be attributed to this success.

First, the early identification of a project gives the students ample time to understand the problem and develop conceptual solutions. Also, requiring them to find an advisor gives them early opportunities to consult with a technical expert. Secondly, one of the major problems with the original capstone design course was that students did not take the time to truly define the problem they were trying to solve or to understand exactly what the final outcome of their work would be. Through three informal presentations to their technical advisor in the first semester, they are forced to develop a formal problem statement that includes requirements, a complete functional diagram of their proposed solution, and a list of deliverables that they will present over the course of the second semester. By committing themselves to an incremental list of partial products, they are creating a self-regulating mechanism for keeping themselves on track. Third, the formal proposal due at the end of the first semester helps cement the faculty's expectations of their project. It also gives the students the opportunity to think through their approach and the risks associated with their project such as availability of parts, etc. Fourth, a rigorous and documented assessment of the technical merit of a student team's project allows the students to objectively assess the worthiness of their project. It has also made the level of effort more consistent between teams which had been a problem in the past.

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