Integrated Team Design

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Abstract

The purpose of the United States Military Academy at West Point is to provide the nation with leaders of character who serve the common defense. In helping to prepare these future leaders for their service to the nation and to the US Army, the Department of Electrical Engineering and Computer Science is chartered to provide a five-course electrical engineering sequence. The purpose of this sequence is to have cadets learn the engineering thought process that culminates with solving an engineering design problem. In addition, the department provides instruction for an ABET-accredited major in electrical engineering. As part of this program, cadets participate in a comprehensive capstone design project. This paper details a unique Military Academy program that provides an integrated design experience for students from both the core engineering sequence and the electrical engineering major's program. By bringing both groups of electrical engineering students together into a single team to accomplish a significant design effort, substantial experience is gained by all. This integrated team approach has proven to be a positive learning experience for both groups as well as for majors from other disciplines in a design team effort.

Introduction

Since its founding in 1802, the United States Military Academy at West Point has been one of the nation's leading undergraduate scientific and engineering institutions. Moreover, the purpose of the Academy is to provide the nation with leaders of character to serve the common defense. This purpose is further defined by the mission statement, "To educate and train the Corps of Cadets so that each graduate shall have the attributes essential to professional growth throughout a career as an officer of the Regular Army and to inspire each to a lifetime of service to the nation." Within the context of the purpose and mission of the Academy, the West Point experience encompasses the academic, military, and physical programs that are inextricably woven together by the thread of cadet moral-ethical development.

The goal of the academic program is to enable graduates to anticipate and respond effectively to the uncertainties of a changing technological, social, political, and economic world. As a result, the curriculum has a core program in the humanities and social sciences and in the basic and applied sciences. An elective program, providing both focused study and enrichment in selected disciplines, complements the core curriculum. One of the specific goals of the academic program is for the cadets to learn to use the engineering process by which mathematical and scientific facts and principles can serve human purposes. To achieve this goal within the core program, all students, regardless of major, must take a five-course engineering sequence in one of seven engineering disciplines that includes electrical engineering. At present, the Department of Electrical Engineering and Computer Science offers a five-course sequence focusing on electronics that culminates with a capstone design experience. Similarly, an optional ABET accredited major in electrical engineering provides a full range of engineering experience that culminates in a comprehensive capstone design experience. This paper details a unique Military Academy program that provides an integrated design experience for cadets from both the core engineering sequence and the electrical engineering major's program. By bringing both groups of electrical engineering students together into a single team to accomplish a significant design effort, a substantial leadership and development experience is gained by both. After providing the framework for the two engineering programs, the concepts of the integrated design approach are detailed. The composition of each design team is also discussed along with the methods of project evaluation. Finally, an assessment of team performance is provided.

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Electrical Engineering Five-course Sequence and Major

The Department of Electrical Engineering and Computer Science supports the Academy goals by providing the five-course sequence in electrical engineering. This sequence is focused on electronic design and serves the purpose of teaching the engineering thought process. The five courses cover digital logic, analog circuit analysis, introductory electronics, senior level electronic design, and the capstone design course and seminar. The student population for this sequence during the current academic year includes cadets whose major fields of study are Life Sciences, Engineering Management, Foreign Language, and Engineering Physics. In a unique effort to consolidate programs, four of these five courses also serve as the fundamental thread of the electrical engineering ABET-accredited major's program. Thus, the cadets who are majoring in electrical engineering also take these same courses in enhanced versions that carry additional design requirements. The design requirements for major's are achieved by augmenting three of the courses with a 0.5 credit hour outside design project. The accredited major's program allows students to take twelve additional courses beyond the five-course sequence for a depth of study in either computer engineering or electrical systems. During the current year, there are 26 cadets majoring in electrical engineering and nine other students taking only the five-course sequence.

Senior Design Project Concept

The electrical engineering senior design project covers the entire sixteen week final semester of the program. Prior to that final semester, students are organized into design teams and required to prepare a proposal that delineates project requirements in technical terms and outlines an initial strategy for solving the design problem. Because the design teams include majors from a variety of disciplines, it is not practical to assign all students to a single capstone design course. Within the program for electrical engineering majors, the computer engineering and electrical systems stems each conclude with a 3.5 credit hour project course that covers digital and analog system design, respectively. Along with the project course, the electrical engineering majors also take a 1.0 credit hour seminar. Students taking only the five-course electrical engineering sequence do not have the same qualifications as the majors, but serve on the same design teams. Their contribution will likely be less and is estimated to be approximately 75% of the effort expected from an electrical engineering major. Therefore, the sequence students are assigned to a separate 3.0 credit hour project course as well as attending the same seminar as the majors. Additional design team members may include majors from other disciplines, such as engineering management or computer science, who receive credit for design project contributions through a standard course in their discipline or an undergraduate research course.

Design problems offered to the students are coordinated among department faculty and, where appropriate, outside organizations such as the Army Research Laboratory. Students are required to provide three prioritized choices from the list of design projects. They are also permitted to name up to two additional students with whom they may want to work on each project. Based on the sign-up process, faculty members determine which projects will be under taken for the current academic year. Typically, more projects are offered than the number of students available. Electrical engineering majors are first assigned to project teams based on a combination of student preferences for projects, student preferences for team members, and instructor recommendations. Before projects are offered to students, requirements are established for the number of electrical engineering majors from each of the two stems, along with the suggested number of sequence students and majors from other disciplines. The target size for each design team is four electrical engineering majors plus students from other disciplines as needed. After three to five electrical engineering majors are assigned to each project, the core sequence students are added to teams based on a number of considerations including past performance, individual skills, choice of project, team leader personality, and advisor opinion or preference. When possible, engineering management majors are added on a one-per-team basis.

When all majors and sequence students have been assigned to a design team, a team leader is designated based on the best qualified volunteer for that position. Each design team then goes through a series of work sessions to analyze requirements and identify the need for students from other disciplines. The supervising faculty member then works with professors from other disciplines to obtain the services of additional students as requested by design team leaders. Team compositions for academic year 1994-95 are shown in Table 1. Students are from the computer engineering and electrical systems stems of the electrical engineering major, as well as other disciplines as shown. All students who are not electrical engineering majors are either in the five-course sequence or the computer science program. No students were sought outside the department during the past year.

Through a somewhat innovative scheduling process, a single faculty member oversees the administration of all electrical engineering project courses. Project advising is more attractive to faculty members in the department if they do not have to personally set milestones, collect reports, or teach design methodology to the design team that they are supervising. Fortunately, the Academy's Operations and

Table 1. Design team composition by discipline

Team 1	Team 2	Team 3	Team 4
2 Cptr Engr Stem 1 Elec Sys Stem 1 Engr Mgt Major 2 Comp Sci Major	4 Cptr Engr Stem	3 Cptr Engr Stem 1 Engr Mgt Major	2 Cptr Engr Stem 1 Engr Mgt Major
Team 5	**Team 6**	**Team 7**	**Team 8**
3 Cptr Engr Stem 1 Elec Sys Stem 1 Life Sciences Major Comp Sci Major	2 Cptr Engr Stem 1 Elec Sys Stem 1 Language Major 2 Engr Mgt Major	3 Elec Sys Stem 1 Physics Major 2 Comp Sci Major	4 Elec Sys Stem

Registrar Division has been willing to schedule all project courses to meet at the same time by blocking out a two-hour period instead of the normal one-hour block. The two-hour block is used for all design methodology and engineering practice lectures, design team meetings, and the electrical engineering seminar. Up to 15 guest speakers are brought in through the seminar course at the proper time to reinforce concepts taught in the project courses.

The faculty member responsible for the project courses establishes all project milestones in cooperation with faculty advisors and maintains all student grades. Grades are assigned based on individual and group performances throughout the semester. Approximately 35% of the student grade is based on assessment of individual performance. Assessment tools include five peer ratings, five individual reports, and a discretionary grade from the primary advisor for each project. The remaining 65% of the overall grade is a measure of team performance based on written and oral proposals, two in-progress reviews, a critical design review, a hardware demonstration, final oral and written reports, and the advisor discretionary evaluation. The grading system allows individual grades within a single design team to range all the way from A through F, but the differential between team members is not likely to exceed two full letter grades.

Assessment of Team Design

An initial evaluation of the integrated design team concept shows it to be an extremely valuable experience for the students. The best three performances were from Teams 1, 5, and 6, respectively, which were heavily interdisciplinary. These were also the only groups that met all specifications by the end of the semester. During the final oral presentation at the end of the semester, students from all groups reiterated that the most critical factor was effective communications between team members. Other student comments referred to the importance of having a team member familiar with project planning and scheduling, the excitement associated with learning about other disciplines, the satisfaction of working on a project that resulted in delivery of a product, the difficulties caused by use of discipline specific language and terminology, the difference between theory and the application of theory, and the fact that the work pace for individuals does not match the desired team work pace.

An important part of the assessment process is the peer ratings which are required approximately every three weeks. Early in the semester, students typically divided the peer rating points equally among all team members. However, by the second rating cycle (the second three weeks of the semester), students were beginning to place actual contributions to the project above friendships or peer pressure to rate everyone the same. Peer ratings were submitted confidentially via electronic mail. An individual technical report was required at the same time as each peer rating. In this report, students were required to describe their individual contributions to the project in several different categories and report the total time spent making that contribution.

Assessment of design team performance and group dynamics will be an ongoing process throughout the next academic year. Some groups have worked exceptionally well, to include the integration of management and computer science majors. Other teams struggled to settle on a solution concept within a reasonable amount of time. The results of the *Myers-Briggs Type Indicator* (MTBI) administered late in the semester show a strong correlation between personality type descriptions and actual team performance. Of particular interest is the initial indication that teams composed of only electrical engineering majors did not perform as well as the interdisciplinary teams. After further analysis, the MTBI will be evaluated as a consideration for assigning

team members.

In addition to topics of interest already mentioned, the conclusion of the semester will allow for additional assessments based on the outgoing student survey, the final written report, and final grades. Data from the five peer ratings will be looked at in terms of individual taskings and student academic discipline. Additional opportunities for study may come from looking into student past performance on design projects such as the major individual project during the previous semester.

Conclusion

This paper describes an interdisciplinary approach to capstone design projects. This approach is new to the electrical engineering program and will be the subject of extensive study in the future. To date, the results of this program are extremely positive. Additional data will be made available in the coming months and appropriate conclusions drawn.

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