BME Undergraduate Design Projects using Various Engineering Majors

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Abstract

For the past four years, undergraduate students in Mechanical, Electrical, and Computer Engineering at LeTourneau University have collaborated via year-long senior design sequences to design, develop, and build an ambitious biomechanical model of an *Intelligent Prosthetic Arm* as a stepping stone for the next generation of prosthetic limbs. While each of these engineering disciplines has their own senior design sequence with separate courses and instructors, one faculty member directs the combined undergraduate team. This unique interdisciplinary undergraduate experience provides a significant opportunity for students to understand how each of their own skills can be enhanced by the skills of other engineering disciplines. The students also gain significant appreciation for how complex projects require the expertise of several disciplines for successful outcomes. The multi-year nature of this project, plus that each interdisciplinary team works collectively for the entire academic year, compels each student to focus on three essential elements: (1) have a clear understanding of the previous year(s) research successes and failures, (2) develop a clearly defined goal for the year, for the entire team and the individual sub-engineering groups, and (3) develop a detailed documentation strategy, i.e., a research notebook, that future teams can easily understand. We have found our teams to be extremely successful in research, while at the same time developing a tremendous awareness of the advantages of working together via an interdisciplinary effort.

I. Introduction

Undergraduate research many times takes a back seat to Industrial or Competition based projects in Senior Design or Capstone Design courses. At LeTourneau University, with its strictly undergraduate engineering student population, our two-semester senior design sequence is one of the few courses in which a faculty member has the opportunity to enlist a number of seniors to participate in funded or un-funded research. Over the last 5 years, over 30 mechanical and electrical engineering students have participated in multi-disciplinary biomedical engineering research projects. These projects have been characteristically in the areas of biomechanics & bio-controls yet incorporate a significant mechanical and electrical engineering design. During the yearlong process, students are enrolled in their respective discipline's senior design course but report to a Project-Technical Advisor during the year. Students taking part in these research projects are required to participate at the Regional ASME meeting both in the poster and oral competition. Since the inception of the teams participating at the regional conference, the teams have performed exceptionally well by either winning first or second place in each category of the competition. These types of senior design projects not only provide engineering synthesis to our students but also the opportunity to do novel research and gain experience in team management and professional oral and written communications.

A unique aspect offered to our engineering student population, which earn a general engineering degree (Bachelor of Science in Engineering, BSE), is the opportunity to supplement their education with a biomedical engineering project. These projects almost always involve a multi-disciplinary approach. Not only do the biomedical topics offer the engineering students the opportunity to implement their broad-based education in mechanical, electrical, and computer engineering, but also because the topics are typically oriented toward basic research, they provide opportunities to widely explore how traditional and innovative engineering techniques can be applied. Students who choose these types of projects are typically interested in working in areas outside of the "ordinary" fields of engineering. The field of biomedical engineering also tends to attract some of the best of our engineering student population, which is typical of what is seen throughout the country (Morrison, 1998).

The combination of a multi-disciplinary student team offers unique challenges and opportunities. For the most part, it allows students to challenge each other with different ways of attacking the problem. Many times students modify their initial analysis based on understanding how their design will impact the "other side of the fence." This redesign often results in an overall more efficient design by encapsulating the best mechanical and electrical components in the design. These distinct design viewpoints help objectives to be tackled more effectively and result in a more successful electromechanical design. Our approach, even in basic research projects, requires students to gain experience in coordinating and executing the research/design/ develop/build process. In essence the nature of our biomedical projects has allowed very open-ended questions to be adequately addressed and an opportunity to work outside of the traditional mode.

II. Project Goals and Milestones

The Technical Advisor typically sets the overall goal of the project. While the project does have a faculty advisor, which is usually the class professor, the technical expertise is found in the technical advisor. The technical advisor, using his/her experience in research and the problem at hand, helps the student team to determine how the overall goal of the project will be achieved. This is especially necessary if the project is funded and requires certain milestones to be accomplished. Students determine benchmarks and subsequent deadlines with the technical advisor's input. In our curriculum, the technical advisor must approve the final timeline and deliverables.

III. Project Implementation

Certain aspects of team management are used to assure the team adheres to the timeline established at the beginning of the project. First, the technical advisor meets weekly with the team's "management" (e.g., project manager, mechanical team leader, electrical team leader, etc.). Two days before the meeting, the project manager is required develop a detailed weekly and cumulative time log, with a description of how each member spent their time and submit this to the technical advisor. During the meeting a minimum of the following items are discussed: (a) accomplishments from the past week are reviewed and evaluated; (b) obstacles which were encountered are discussed for validity; (c) goals for the following week are determined; (d)

impact on the overall timeline is discussed and contingencies are developed if necessary; and (e) technical guidance is provided as needed. Monthly meetings are also scheduled with the entire team. During this time the following aspects are discussed: (a) review how the team is functioning as a whole, e.g. distribution of work load, interpersonal relationships, task allocations, etc.; (b) accomplishments of the past month are accessed; (c) goals for the next month are determined; (d) impact on the overall timeline is accessed; (e) budget items are discussed; and (e) advisor guidance is provided as needed.

IV. Presenting the Project

As previously discussed, a completed physical demonstration is necessary for project completion. This demonstration of the team's final design and findings is presented at the end of the two-semester sequence. The audience consists of students, faculty, and the customer. These presentations are open to anyone. In addition, a significant requirement is that the team must also present their results at the regional ASME conference in both the oral and poster competitions. These undergraduate conferences further expose the students' research to a wider audience and evaluate their skills against peers at similar institutions. Two posters are typically presented at the ASME regional conference, one encompassing the mechanical aspects of the project and the second on the electromechanical aspects of the project. At least one technical conference paper is required from the project and must be submitted and accepted to an appropriate conference (ASME-BME, ASB, IEEE, etc.)

V. Conclusions

Biomedical research projects add a considerable amount of educational experience to undergraduate students due to their multi-disciplinary requirements. First, students learn a great deal about the research process; that is, how one proceeds from an introductory exploratory question to a demonstrable final design. Second, students learn the process of moving from research / design / development / build and the problems encountered in each individual phase and transitory stages. Third, the team leaders learn how to manage a multidisciplinary team of engineers. This exposes students to the reality that it takes more than technical expertise to make a project successful - it takes proficient management of the personnel and financial aspects. Fourth, the team learns to develop effective presentations - both oral and written. This is accomplished through weekly meetings with the technical advisor, class presentations, and final competitions at regional undergraduate conferences. Fifth, students gain a glimpse of graduate level research. This inspires some students to pursue a graduate degree, but is for others an incentive to enter the job market.

A demonstration of the accomplishments of biomedical engineering projects is realized by LeTourneau University engineering students' continued success at regional competitions. During the last three years our BME senior design teams have earned 1st place in regional competition and twice winning 2nd place in national competition.

Bibliography

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