BIOMEDICAL ENGINEERING SENIOR DESIGN

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I. Introduction

In most senior design courses, the emphasis is not on learning new material, but rather solving large-scale, open-ended, complex and sometimes ill-defined problems. This is an iterative, decision-making process in which the students apply previously learned material to meet a stated objective. Most often, students are exposed to system-wide synthesis and analysis, critique and evaluation for the first time. Typically, the class is divided into small teams of no more than 5 students. Each team meets with the course instructors and faculty advisors on a regular basis, and when appropriate, with clinicians and industrial sponsors. Some programs have teams consisting only of biomedical engineering students, while other programs offer truly interdisciplinary teams of biomedical, electrical, mechanical and chemical engineers. For example, at Marquette University[1], all senior biomedical, electrical and mechanical engineering students are combined into one capstone design course where students may select projects offered by any of the participating departments. Project sponsors typically request that a team be comprised of a mix of engineering disciplines.

Typically, there are no required textbooks, and only a minimal number of lectures. Experts from industry, patent law and government agencies typically provide the lecture material. Students integrate and apply knowledge from their major field of study toward a specific project.

A number of biomedical engineering programs, like the University of Connecticut[2], have a full year of required senior design courses, here referred to as Design I and II. The major deliverable in Design I is a paper design with extensive modeling and computer analysis. Over the semester, students are introduced to a variety of subjects including working on teams, the design process, planning and scheduling, technical report writing, proposal writing, oral presentations, ethics in design, safety, liability, impact of economic constraints, environmental considerations, manufacturing and marketing. Design II requires students to implement their design by completing a working model of the final product. Prototype testing of the paper design typically requires modification to meet specifications.

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The major milestones in Design I are: select project, draft specifications, prepare project proposal, create a time-line, select an optimal solution, carry out a feasibility study, specify components, conduct a cost analysis. In Design II, students: construct and test a prototype using modular components as appropriate, conduct system integration and testing, assemble final product and field-test the device, write a final project report and an operator manual, and present an oral report.

III. Team Work

Graduates entering the real-world find that just about every project is tackled by a team of engineers, scientists, marketing experts, technicians and other personnel. Yet, team-based projects tend to be difficult for a student without the basic team-building skills in his or her background.[3] Student learning styles differ within teams and are best described by field independent and field dependent learners. Field independent learners tend to be excellent problem solvers and independent workers, people who would rather work by themselves than interact in a group. These type of learners typically have trouble communicating with others and need private time to clarify ideas and solutions. Field dependent learners are excellent communicators and need the interaction of the team to clarify ideas and solutions. These learners tend to work optimally within groups and without group interaction would tend to fail.

On a team-based project, each student has tasks that he or she is responsible for successfully completing, and team success depends on each team member completing his or her own tasks. Naturally, team success depends on each team member communicating progress on a regular basis – this interaction is vital for the team to complete the project.

IV. Communication

Throughout the design process, students are required to document their work through a series of required written assignments as well as a bound, project notebook. For the final report, documenting the design project involves integrating each of the required reports into a single final document. Students are often expected to record weekly progress in bound, legal notebooks and on a WWW site.[4] Many graded written reports are required throughout the first semester that culminates in a final report for the project. Successive updating of common elements of over multiple reports allows the students to improve his or her writing skills. The WEB is being used more often to report project progress and communicate with the sponsors and clients.

Students are also required to give oral presentations such as weekly design reviews to fellow team members and faculty advisors and end-of-semester formal presentations to the entire class and clients. At Boston University, the BME program has a senior project conference, which draws representatives from more than 50 biomedical companies and local hospitals, providing a professional style forum for every student to present his or her project orally.[5]

V. Time Lines and Team Meetings

Oftentimes, one or more students on a team are less industrious than others, which can result in a less than satisfactory, but still passable project, or a project that is unsatisfactory.[6] While the training in team skills, use of a time-line and team meetings can reduce the possibility of the latter case, this case is still an unpleasant possibility. Time-line development by the team is usually vital for success, eliminates most management issues and allows the instructor to monitor the activities by student team members. For this to be a success, activities for each week need to be documented for each team member, with best success when 5-10 activities per team member each week. When this is done, the team knows what needs to be done and will be successful in completing the project.

VI. Evaluation

Methods of evaluation vary considerably across programs, but most allow for both team grades and individual grades. In most courses, a student is individually accountable for his or her own grade. In a course with team-based accomplishments, grading is based on the success of the team and possibly the success of an individual on that team.[7]

One or more faculty typically grade written reports required throughout the semester. In some cases, clients other than faculty contribute to the evaluation process. Oral presentations may be evaluated by class members external to the presenting design team. In addition to faculty evaluations on individual and team performance, students may receive peer evaluations. Some programs even use formal written exams as part of the evaluation process.

VII. Computer Technology and WWW

Computer technology and the WWW will continue to facilitate the design process and communication in the future. From simple Power Point presentations and WWW pages logging project status to Microsoft project for time-lines and project planning to modeling and simulation software to NetMeeting and video conferencing for distant clients and collaborations.

VIII. Projects to Aid Persons with Disabilities

In 1988, the National Science Foundation (NSF) began a program[7,8,9,10] to provide funds for student engineers to construct custom designed devices and software for disabled individuals. This provides universities an opportunity for a unique service to the local community. An individual with a disability receives a device that provides a significant improvement in the quality of his or her life at no cost to the disabled individual. The program also motivates students, graduate engineers and other health care professionals to work more actively in rehabilitation, towards an increased technology and knowledge base, to effectively address the needs of the disabled.

Approximately twenty universities have been involved with this program on a yearly basis. Projects built in years past include a laser-pointing device for people who cannot use their hands, a speech aid, a behavior modification device, a hands-free automatic answering and hang-up telephone system, and an infrared beacon to help a blind person move around a room. Many of the projects carried out in this program have been highlighted in conference publications, national radio, local TV news programs, local newspapers, CNN, as well as the ASEE Engineering Education Magazine.

The students participating in this program have been singularly rewarded through their activity with the disabled, and have justly experienced a unique sense of purpose and pride in their accomplishment.

IX. Conclusion

This paper provides an overview of an approach to senior design. The senior design program described here is highly structured, provides background in team building and communication among other engineering topics, and makes use of a time-line approach. A multidisciplinary focus is encouraged in senior design since difficult engineering problems can be uniquely solved with input from multiple knowledge sources and perspectives. Team skills should be developed early and used throughout the curriculum and not just in senior design.

Biography

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