

A DESIGN BACKBONE FOR THE BIOMEDICAL ENGINEERING CURRICULUM

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Abstract- In this paper, we summarize our experiences as advisors supervising biomedical engineering design projects in the design backbone of our curriculum, the six-semester design course sequence required for all biomedical engineering majors at the University of Wisconsin-Madison.

Keywords - Design course, client-based design, service learning

I. INTRODUCTION

When we created our new undergraduate degree in biomedical engineering at the University of Wisconsin-Madison [1], we were concerned that students would be getting too much of the knowledge of science and not enough of the spirit of engineering. This concern was in part due to the extra courses in chemistry, biology, and physiology required in biomedical engineering that most engineering majors do not take. Therefore we decided to use the attribute that best defines engineering—design—as the backbone of the curriculum. After admission at the beginning of the sophomore year, all biomedical engineering majors take a design course every semester throughout their curriculum. These six design courses constitute a total of eight semester degree credits.

All engineering students at Wisconsin start in pre-engineering during their freshman year and are not admitted into departments until the sophomore year. We strongly recommend to students intending to become BME majors that they elect to take the general freshman engineering design course, Introduction to Engineering, during their first university semester [2]. This course includes students who will ultimately enter different engineering disciplines. In their second semester, we recommend that intended BME majors enroll in a biomedical engineering project in the EPICS (Engineering Projects in Community Service) program [3]. EPICS provides a design experience that includes all engineering disciplines and vertically integrates students from all college years.

II. DESIGN CURRICULUM BACKBONE

BME majors take BME design courses starting the first semester of the sophomore year and continuing every semester throughout the curriculum [4]. All the courses are one credit except the capstone design course in the first semester of the senior year which is three-credits. We see the design sequence as the backbone of the curriculum, a theme that continues throughout the degree program, where students have the opportunity to apply the knowledge that they are gaining in their other courses to the design process and to see the relevance of the material that they are learning.

All the design projects are client-based, real-world design problems, solicited primarily from the medical and life sciences faculty around the university, as well as from biomedical engineering companies, and occasionally from individuals with specific needs. The faculty team reviews the proposed projects and chooses those that we believe are well matched to the students' abilities and likely to result in physical prototypes. Each team of students then interacts with their client and advisor to define the specifications for their project. Each client maintains a dialog with the design team throughout the course, providing meaningful feedback as the design progresses, and access to the appropriate clinical or research setting. Faculty are fully responsible for all aspects of the design courses. We do not use teaching assistants. Each faculty member has a weekly two-hour meeting in a computer lab with his/her teams.

All design courses require the following deliverables as well as the final design and physical prototype:

1. Each student keeps an engineering notebook.
2. Each team submits a weekly progress report to their advisor and client by email.
3. Each team does a mid-semester PowerPoint presentation and written report.
4. Each team produces an end-of-semester final report.
5. Each team maintains a web site.
6. Each team does an end-of-semester poster presentation.
7. Each student does a self and peer performance evaluation.

The courses are organized as shown in Fig. 1. In the first semester of both the sophomore and junior courses (BME 200/300), a design team typically consists of eight students—half sophomores and half juniors. Each first-semester sophomore is paired with a first-semester junior, who serves as a peer mentor in the design process, and also as a peer advisor on issues such as course and area choices that go beyond the immediate goals of the course. The team is divided into these sophomore-junior pairs who form four subgroups which each develop a conceptual design for the first third of the semester. In this approach, the sophomores have the opportunity to learn the design process from the more experienced juniors. For the final two-thirds of the semester, the subgroups join together as eight-person teams to complete the final design and prototype implementation.

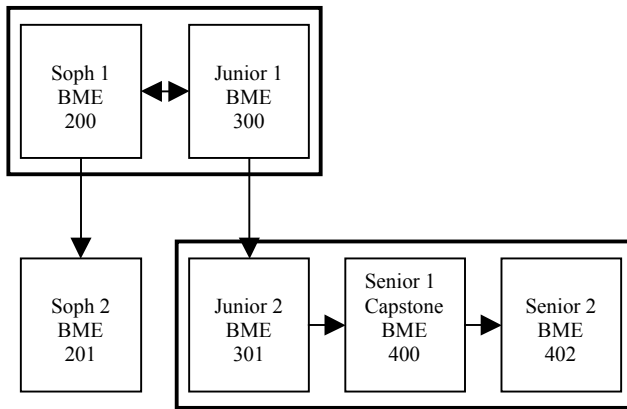


Fig. 1. Functional grouping of BME design courses.

After the first semester sophomore-junior experience, the second semester sophomores (BME 201) work as four-person teams on different design projects. The second-semester juniors begin a three-semester design sequence (BME 301, 400, and 402) in four-person teams that starts with planning and pilot studies intended to lead to the three-credit capstone design project in the first semester of their senior year. Their final one-credit design course in the last semester of their degree program is dedicated to testing, evaluation, and documentation of their capstone design project. Also they have an outreach requirement in which they must give a presentation in a K-12 school about their design project. In addition, they must write a technical paper with their client suitable for publication or file for a patent with the university's patent organization.

In the Spring semester of 2002, we had seven faculty involved in teaching the design courses—three for the sophomore course and two each for the junior and senior courses. Each course had about 32 students and either eight or nine design teams, each working on a different project. The typical team size was four students but some teams had as few as two or as many as five students. Each faculty member was responsible for advising between three and five design projects. We had a total of 26 different active projects in the three courses. All the teams in each class met together with their advisors in the same computer lab for a two-hour period each week. The advisors limited teaching activities at the beginning of each lab to a maximum of 20 minutes to leave most of the time for the students to work on their projects. In these sessions, we focused on such topics as the design process, ethics case studies, human and animal research protocols, and guidelines for presentations and technical writing.

III. DESIGNING A BETTER BME CURRICULUM

As a part of the design courses, each semester one member of each design team serves as a representative to the Biomedical Student Advisory Committee (BSAC). The charge of this committee is to provide timely feedback to the faculty for improving the design course sequence as well as other aspects of the curriculum. This is a very active committee

that meets together biweekly and once monthly with the faculty. Over the years, BSAC has provided us with many valuable suggestions on ways to improve the curriculum, many of which have already been implemented.

A second member of each team serves with the Biomedical Web Implementation Group (BWIG). This group is responsible for developing and maintaining the design project web site [5]. This site includes summaries of the 26 projects that were in progress in the Spring semester of 2002.

IV. CONCLUSION

The beginning BME design course uses junior students to mentor sophomores, which we think is a valuable approach. The design backbone structure also provides a three-semester junior-senior design sequence so that projects can be conducted over a reasonably long time span. Although all BME students are in one department, they each have traditional engineering concentrations (e.g., bioinstrumentation, biomechanics), so a BME team is by its nature multidisciplinary. Interaction with medical clients provides clinical familiarization that might not otherwise be available to undergraduates. We believe that the curriculum design backbone is an effective strategy for stimulating learning in biomedical engineering majors and will be beneficial to them regardless of whether they choose to continue their careers in engineering, medicine, or any other field.

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REFERENCES

- [1] For more information about the biomedical engineering curriculum, see: <http://www.engr.wisc.edu/bme/>.
- [2] For more information about the freshman design course, see: <http://www.cae.wisc.edu/~epd160/>.
- [3] For more information about EPICS, see: <http://epics.engr.wisc.edu/>.
- [4] To learn more about the design courses, go to: <http://www.engr.wisc.edu/bme/courses/> and select the courses, BME 200, 201, 300, 301, 400, and 402.
- [5] For summaries of the current design projects, see: <http://www.cae.wisc.edu/~bmedesgn/>