

AC 2007-1829: DEVELOPING A BIOMEDICAL ENGINEERING FOCUS WHILE MAINTAINING A STRONG ELECTRICAL ENGINEERING CURRICULUM

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Developing a Biomedical Engineering Focus while Maintaining a Strong Electrical Engineering Curriculum

Abstract

There is a growing need to train talented engineers that can develop technology at the boundary between the biological/medical sciences and engineering. Engineers that can communicate effectively with biologists and medical doctors as they solve the problems facing modern health care. While the implementation of a complete biomedical engineering curriculum may be one approach to address this need, it weakens the electrical engineering training received by the students. Hence, there remains a need for electrical engineers highly trained in circuit and system design that also understand the basics of biology, anatomy, and physiology. Therefore, we developed a biomedical engineering focus program within our electrical engineering department that provides training in the biological sciences while maintaining our strong emphasis in circuits and systems. The developed curriculum also utilized the courses already offered in other colleges minimizing the need to develop new courses within the department. This allows the program to be implemented in departments with fewer faculty members. In addition to meeting the needs of the future engineering workforce, we also hope that the program will attract talented young women to electrical engineering improving the diversity of our electrical engineering program.

Introduction

Many of the most successful companies in the United States today are developing technology at the boundary between the biological sciences and the traditional engineering disciplines. Companies like Medtronic, GE Healthcare, Siemens, Johnson & Johnson are all redefining medicine through innovative technology. Therefore, there is a high demand for talented engineers that are able to work and communicate at this interface. Although some schools have decided to meet this challenge by offering a biomedical engineering major, this may not be a practical solution for smaller engineering schools with limited faculty and resources. Furthermore, as one representative from a large biomedical company recently mentioned in a private conversation, the current biomedical engineering graduates lack the depth of skills needed to be marketable. Rather, they tend to be broadly trained in many areas but lack the focused training to take technology to the marketplace. Therefore, at the University of North Dakota we endeavored to develop a focus program within Electrical Engineering that would give our students the skills and vocabulary to communicate effectively with professionals in the medical field while still retaining the training to be successful electrical engineers.

Design of Program

When designing the focus program in biomedical engineering, we had four goals. First, we wanted to train our students to be knowledgeable in the life sciences so that they could effectively communicate with healthcare professionals, understand their needs, and translate these needs into engineering design specifications. Second, we wanted to continue to train our students as competent electrical engineers so that they could contribute to the design of

biomedical engineering devices. Third, the program would need to minimize the development of new courses within the department due to the limited amount of faculty resources in our small department. Lastly, the program should be compatible with admission into medical school should our students decide to leave the traditional engineering pathway and endeavor to become medical doctors.

In order to achieve the first goal of training our students to work at the boundary between medicine and engineering, courses in the life sciences involving biology, anatomy, and physiology needed to be added to the curriculum. Although some engineering schools attempt to teach life science concepts within the confines of their own curriculum, this is contrary to one of the main reasons the students need the courses. Namely, the students need to learn to communicate with health care professionals. By taking life science courses with the pre-medical students, they will have the opportunity to interact with these students. As the students learn and discuss the material together, they will gain experience communicating with each other. Another benefit to having the students take the established courses being offered by other departments is that it minimizes the demand made by the focus program on faculty resources which was also our third goal. Therefore, when designing the biomedical engineering focus program, we capitalized as much as possible on the courses already being offered by other departments on campus.

The fourth goal of having the developed focus program be compatible with admission into medical school was achieved by discussing the proposed course work with the pre-medicine advisor on our campus. Although, not all of the suggested pre-medicine courses could be included due to our desire of maintaining a strong electrical engineering curriculum (i.e., lacking two semesters of organic chemistry, course in biochemistry, and course in genetics), all of the life science courses added when forming the focus program are also suggested for students planning to study medicine. Therefore, the students would be able to enter medical school with only a minimal amount of additional schooling (~ 1 additional academic year, less if summer classes are taken).

Overview of Program

The Biomedical Engineering Focus program that was developed required that five additional courses be inserted into the curriculum. These courses are provided in Table 1. Although these courses are specific to our institution, there are similar courses at other institutions that could be added if a similar program were to be implemented.

Table 1: Courses added for the biomedical focus program.

Course Name	Number of Credits
General Biology 1 (w/ Laboratory)	4
General Biology 2 (w/ Laboratory)	4
General Chemistry 2* (w/ Laboratory)	4
Anatomy	3
Human Physiology (w/ Laboratory)	4

*General Chemistry 1 (w/ Laboratory) is already part of our curriculum.

The purpose of the general biology and chemistry courses is to lay the groundwork for the more advanced anatomy and human physiology courses. The anatomy course provides an overview of human gross anatomy. This will allow the students to become familiar with the basic workings of the human body and the purpose of each of the major organ systems. The human physiology course, which will be taken in the senior year, will serve as a capstone type of course for the life sciences portion of the curriculum. In this course, the students will obtain a greater understanding of the workings of the human body in terms of the mechanical, physical, and biochemical functions of normal human tissues and organs. With this background, the students will be able to communicate intelligently with health care professionals as well as begin to design systems that interact with the human body.

Like most electrical engineering curriculum, our curriculum is very demanding. Therefore, these courses could not be added without other courses being removed. Table 2 provides a list of the courses in our curriculum that were removed when designing the focus program.

Table 2: Courses removed from curriculum for the biomedical focus program.

Course Description	Number of Credits
Math Elective	3
Technical Elective	6
Electrical Engineering Elective	3
Basic/Applied Science Elective	3
Computer-Aided Graphical Design Course	3

Since the goal was to retain a strong traditional electrical engineering program within the biomedical focus program (second goal), none of the core electrical engineering courses were removed. With the exception of the computer-aided graphical design course, all of the courses were electives primarily offered outside of electrical engineering. Although three electrical engineering elective credits were dropped when forming the focus program, six electrical engineering elective credits were retained allowing for the students to still acquire depth in areas of interest in electrical engineering. Furthermore, the curriculum for the focus program still satisfied the ABET requirements by having 46 credits in the Math and Basic Science category (minimum credit requirement of 32 credits) and 64 credits (55 credits in electrical engineering, 9 credits in other areas of engineering) in the Engineering Topics category (minimum credit requirement of 48 credits).

Conclusions

We were able to successfully develop a biomedical engineering focus program within our department of electrical engineering. The developed focus will allow our students to be trained in the life sciences, so that they may become valuable members in biomedical technology development in the future. Also, unlike a biomedical engineering degree that can produce graduates lacking the skills to contribute in a commercial setting while demanding significant college resources, the developed program was built by adding only a few life science courses that were already being offered by other departments on campus. Therefore, our graduates will still

be highly trained electrical engineers only with the additional ability to understand and communicate with medical professionals. The goal of a college education is not to teach our students everything that they will ever need to know. Rather, we are only to provide the tools they need to continue learning throughout their professional careers. Therefore, learning the basics of electrical engineering and medicine will provide them with the tools they need to be successful innovators in biomedical engineering as well as allow them to collaborate with medical professionals in the future. We hope that other electrical engineering programs will be able to implement a similar focus area in biomedical engineering broadening the training available at their institution.