# AC 2008-289: A NEW CLASS COVERING HEALTH CARE TECHNOLOGIES

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# A New Class Covering Health Care Technologies


## Abstract

Due to the rapid growth of the healthcare industry, an unmet need exists for recent graduates with interdisciplinary experience to work in the sales, maintenance, distribution, and repair of devices used in the healthcare industry. According to conversations with industry members, such jobs are often undesired by the only students with adequate interdisciplinary background that graduate from Biomedical Engineering departments. In Fall 2007, a new class was developed to serve as a technical elective for both Industrial Distribution students and Electrical Engineering Technology students. In the hopes of assisting the creation of similar classes in the future, this paper details the class structure, the topics covered, and the difficulties encountered in the inaugural semester.


## I. Introduction

Medical devices are interdisciplinary and to fully understand them requires knowledge in such fields as medicine, engineering, and computer science. The healthcare industry is a large field, the largest industry in the US in 2006 with 14 million jobs[1], and contains many jobs for selling/making/maintaining medical devices but optimal performance at those positions requires interdisciplinary knowledge to some degree. The majority of college students do not acquire sufficient interdisciplinary experience to prepare them not only for performing such jobs but also for evaluating whether or not they would like to work in the medical device industry. Meanwhile companies provide some training for new hires, but welcome college classes that help students to develop a broad view of technological devices used in healthcare. Most college classes focused on medical devices are offered by biomedical engineering departments and may be impractical for students in other disciplines such as computer science or industrial distribution. This paper describes a class developed in Fall 2007 to survey devices used in hospitals for students of widely varying backgrounds and interests. The goal of this paper is to inform the creation of similar classes at other institutions.

The aim in developing this class was to provide the students with an overview of selected healthcare devices. Through exit interviews with graduating students, discussions with industry members, and guidance from the department head and dean, an opportunity was identified to satisfy student interests and industry needs with regards to the medical device industry. For each device covered, the material includes the reason healthcare personnel would use the device, what it does, the physics behind how it works, any physiology necessary to understand its usage, and the main complications with the device. The class focuses on devices regularly found in hospitals and whose operation the students are unlikely to understand prior to taking the class. For example, several types of imaging were discussed, but not the operation of wheelchairs or adjustable beds.

Two constraints shaped the course structure, the student population and the elective nature of the class. First, the class is attended by students ranging from Sophomores to Seniors, from both the Industrial Distribution and Electrical Engineering Technology programs. This constraint made it infeasible to copy an existing course; most courses on medical devices are offered in biomedical engineering departments to students who can be expected to exhibit interest both in the use of the devices and in any underlying engineering factors. In comparison, this class must strive to add value to a mix of students including those who are uninterested in the engineering details but interested in where the device components are manufactured. Second, as a technical elective, the course had to be either three hours of lecture per week or two hours of lecture plus two hours of lab per week, so as to have the same number of credit hours as other electives. As a final consideration, the class size is expected to be between 10 and 20 students per semester, a size conducive to group work and in-class discussion.

## II. A study of the first semester

The first semester was taken by sixteen students, and was taught primarily through lectures, with two field trips, two in-class exams, and two sets of student presentations. The choice of lecture topics was influenced by, but not constrained to, the textbook material. Grading was primarily based off exams and presentations, with some consideration for homework and attendance.

Lecture topics included: a general healthcare history, electrocardiograms, defibrillators, cardioverters, ventricular assist devices, sphygmomanometers, $H_2O$ manometers, electric pressure transducers, dilution techniques, plethysmographs, phonocardiography, catheters, pacemakers, heart-lung machines, pneumographs, spirometers, electroencephalography, bedside monitors, telemetry systems, blood cell analyzers, blood oximeters, hemodialysis, ultrasound, electrosurgery, lasers, x-rays, computed tomography, Positron Emission Tomography, Magnetic Resonance Imaging, electromagnetic interference, and prosthetics. These topics were chosen in an attempt to cover the majority of imaging, measurement, and therapy devices used in the healthcare field while excluding any devices whose use and purpose could be considered common knowledge such as stethoscopes and scalpels. A general outline was followed for each device: an overview of the physiology and anatomy of any targeted organs, typical diseases that can affect the organs, the purpose and use of the device, the physics of how the device works, any important manufacturing/distribution/maintenance details (e.g., complicated circuitry or the need for superconductors), and prominent complications or failure modes for the device.

With the notable exception of Magnetic Resonance Imaging, most of these topics were described in the required textbook by Carr and Brown.[2] The textbook provided the students with a second source to learn the material and initially was used to assign homework problems. 5 of the 27 chapters in the book described circuitry for instrumentation and measurement in too much technical detail for the purpose of the class and were therefore skipped, but the majority of the rest of the book was addressed to some degree in class. Other books that were considered include those by Enderle, Blanchard, and Bronzino[3]; Feinberg[4]; Webster[5]; and Bronzino[6], but all were determined to have more of a technical focus than was desired. A summary of textbooks available as of 1998 for introduction to Biomedical Engineering was provided by Blanchard and Enderle, and lists the most promising textbooks for such a class.[7]

Some additional topics that were considered but not covered are the Picture Archiving and Communication System (PACS), device acquisition/management, maintenance facilities, quality assurance, and the many standards that apply to medical devices. Though widespread and vital to the operation of modern hospitals, PACS is simple to understand in overview, consisting of networked computers dedicated to handling images in a specified format. Device acquisition/management procedures and maintenance facilities contain many details that are location-dependent. Medical standards and quality assurance are broad fields that may not add value for many of the students taking the class based on their expected future jobs. Future semester may include brief coverage of interesting devices with a more tenuous connection to the medical field, with a less common occurrence, or with the future potential for medical importance, such as backscatter x-ray machines, surgical robots, or magnetoencephalography, respectively.

The decision to exclude labs rested on the expectation that the material would require three hours of lecture per week and on the perceived difficulty in developing pertinent labs within the comfort levels of all the students. The downside of not having labs is a lack of hands-on experience with representative devices. A similar experience can be gained by seeing the devices in use during field trips and for this reason two field trips of one hour each were scheduled during the semester.  The first field trip was to an animal hospital that treats small animals such as dogs and cats. As most of the equipment used in small animal hospitals is identical or equivalent to the equipment used in human hospitals, the students were able to observe demonstrations of spirometers, blood oximeters, combined electrocardiogram/defibrillators, surgical equipment, and x-ray machines. The second field trip was to a human hospital and was spent observing and discussing various forms of imaging with radiologists. In both cases the medical personnel were very helpful and did a good job of quickly showing the students around a medical environment and answering any questions. Judging the educational benefit of a field trip is difficult, but including at least one field trip in the class seems vital to show the students the “everyday life” of some medical devices. The benefit sharply drops off after the first field trip as the students have already observed a medical environment, albeit during a tour containing different devices at a different hospital. Instead, the second trip focused on discussions with the medical personnel.

Soon into the semester the schedule was adjusted to include student presentations in an effort to encourage active participation in the material and to allow each student to direct their own learning to some degree. Before then the homework has been assigned from the book, but after that point homework assignments consisted of preparatory work for both the end-of-semester presentations and a short presentation at mid-semester designed to give early feedback. For example, one homework assignment required contacting industry representatives and determining common options for the device the student was planning to present. The presentations were of varied quality both in terms of the material that was presented and the method of presentation. The mid-semester presentations did a good job of correcting the most egregious violations of good presentation style, such as unreadable fonts and the lack of useful content throughout an entire presentation. Still, with just two presentations per student for the entire semester, the students did not receive enough feedback and practice for all of them to effectively present their chosen device to the class. This lack of ability was most obvious when two students chose the same device and then performed at different levels in learning about the device and/or presenting what they had learned.

The most surprising observation about the presentations was that few students did a reasonable job incorporating the work they had done on the homework assignments into the presentations. Several assignments involved talking with industry representatives or investigating the variations between models of a device, and yet the majority of the presentations contained little more information than could be gleaned from a search on the internet. It is apparent that the students viewed the homework and presentations as two separate entities even though the homework was routinely referred to as presentation preparation.

Throughout the semester, informal questionnaires provided insights into the students' opinions about the strong and weak areas of the class structure. These questionnaires also generated several ideas for improving the class, such as further topics for discussion. The students were very positive about the questionnaires, and enjoyed the feeling that they could affect the direction or structure of the class. Mostly the students used the questionnaires to communicate a desire for the homework to be more meaningful than the book's fill-in-the-blank problems, and to suggest vague changes in focus, e.g., "I would like to see more new devices."

**III. Results**

On the informal questionnaires and in regular conversations, the students have been uniformly supportive of the class, and the formal evaluations were good at 4.7 on a 1-5 scale. Their only quibble is that they tend to ask that the class material more closely fit with their other classes. For example, the industrial distribution students want the class to cover the sales of various devices, while the engineering technology students want the class to cover relevant circuit diagrams. Given the dissimilar backgrounds of the two groups of students, the in-depth material requested by either group would be incomprehensible or uninteresting to the other group. These desires have led to an increasing emphasis on the student presentations and on the development of homework that supports investigations in multiple directions. For example, once the students have determined common options for their devices, they can either investigate the circuitry for those options or the effect those options have on sales.

Fellow faculty member opinions about the topics covered in the class have been unanimously positive even as they recommend methods for improving the class. Recommendations have included other textbooks to consider, surveying industry about the appropriateness of the covered topics, and bringing in outside speakers such as radiologists or hospital staff in charge of equipment acquisition. A survey of members of the medical device industry will be performed this year to evaluate the material covered in the class from the standpoint of potential employers. Those invited to participate in the survey will be chosen from the companies considered most likely to hire students from our department, including local companies, companies that have previously hired students from the department, and pre-existing contacts of departmental faculty. As the professor, I believe the class has been well prepared to achieve the goal of providing students with a basic knowledge of medical devices, but that significant opportunities for improvement exist. The course materials and any future modifications will be made available on the department's website to assist the development of similar classes in other institutions.

**IV. Difficulties and potential solutions**

The primary difficulty is preventing the class from becoming a collection of unconnected details such that the students gain little long term benefit. The class is intended to be a survey of medical devices and combining that goal with the fact that the students are not involved in similar disciplines complicates emphasizing the connections between different topics. To combat this tendency towards less detail, the lecture material for each device followed the same format as described in the above section. In future semesters the solution seems to be linking the topics by similarities in manufacturing, device use, and markets, while providing more details on the circuitry and distribution of each device.

A secondary difficulty lies in motivating the students to think critically about the class subject. The attitudes of the students tended towards passive learning, and ultimately led to a general lack of learning more than the most general facts and most entertaining anecdotes. This attitude is noticeable in the grades for the presentations, which were determined by combining student and instructor evaluations. Many students did a poor job of evaluating their peers, being primarily influenced by the visual impact and polish of the presentations while ignoring the content or lack thereof. The students' evaluation forms were generally sparse on comments, suggesting that the students were not critically approaching the presentations and were instead approaching them with the attitude of being passively entertained. The root causes of this problem are the lack of student experience with the topic and the large knowledge base required to understand the material, including physiology, anatomy, electronics, and physics. The combination of these issues hinders in-class discussion and leads the students to passive roles in the classroom environment.

Student presentations were the chosen approach to enhancing student involvement and depth of learning, but some issues should be addressed with such presentations. Allowing the students to choose their own device to present did provide some students with the opportunity to investigate material they found inherently interesting, but the majority of students picked a device that had already been mentioned in the lectures and did not seem to have any emotional investment in their choice. For future semesters the plan is to provide a list of devices to select from along with the option for the students to suggest any device not on the list and to limit each device to a single student. Furthermore, requiring student presentations is not enough to ensure active participation in the class as the students can then view their peers' presentations as passive entertainment. One recommendation is to extend student responsibility to the point of having moderators and discussion leaders, but the correct way to motivate involvement is uncertain.

Other approaches that have been considered for improving student involvement include having students lead the class, prepare homework, and design exam problems. Taking this idea further, the students could be responsible for regular presentations in small groups with assigned topics. The benefit of regular presentations is to further ease the path to active learning by allowing an iterative approach to the topics. During or after the presentations, the class would be expected to ask questions and then the presenting group would perform further investigation of the material and later give another presentation to answer those questions. Once the topic has been explored to the satisfaction of the instructor and the class, a new topic would be chosen. Regular presentations also provide the students with enough experience working in groups for peer evaluations to play a role in final grades.

The method that has been most recommended for encouraging active learning in the class is through project-based learning, such as investigating real-world problems, working with actual medical equipment, and by holding regular laboratory exercises. Incorporating projects would require some restructuring of the class, but may be synergistic with the regular group presentations being considered. In the first semester, labs were neglected in place of lecture due to the sheer number of devices to be discussed and the fact that labs tend to focus time on a small number of topics. Having taught the class, time is not so much of an issue and reducing the lecture time to add labs is feasible as long as the labs require an appropriate technical knowledge for the students in the class.

Finding a textbook with the right focus is difficult. I have yet to find a book that gives a modern look at a broad range of medical devices and relevant physiology without going too deeply into details. For future semesters, I plan to recommend the book by Carr and Brown but tell the students to perform internet searches to read about devices before each class.

Though such difficulties and opportunities for improvement exist, in the first semester the students seemed to retain the material covered in class and recommended the class to their colleagues. Future changes can be expected to only improve the impact of the class in providing students with an overview of medical devices suitable to inform their decisions about whether to enter the medical device industry and to ease their entry into that industry. It is my hope that by informing students in this manner, a rapport will be developed between the department and medical device companies to the benefit of both.

## V. References


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