# Clinical Immersion in a Classroom Setting (Work in Progress)

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Dr. Zapanta's primary teaching responsibilities are Biomedical Engineering Laboratory and Design. Additional teaching interests include medical device design education and professional issues in biomedical engineering. Dr. Zapanta's responsibilities as Associate Department head include overseeing the undergraduate curriculum and undergraduate student advising.

Dr. Zapanta's research interests are in developing medical devices to treat cardiovascular disease, focusing on the areas of cardiac assist devices and prosthetic heart valves. Dr. Zapanta is an active member in the American Society for Artificial Internal Organs, American Society of Mechanical Engineers, the American Society for Engineering Education, and the Biomedical Engineering Society. He is a reviewer for several biomedical engineering journals. Dr. Zapanta also serves as a reviewer for the National Institutes of Health (NIH), Cardiovascular Sciences Small Business Special Emphasis Panel and as an ABET Program Evaluator (PEV) for Bioengineering and Biomedical Engineering programs.

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David C. Whitcomb MD, PhD is the Giant Eagle Foundation Professor of Cancer Genetics, a Professor of Medicine (with tenure), Cell Biology and Physiology, and Human Genetic at the University of Pittsburgh, and Director of the Precision Medicine Service at UPMC. Training includes a BS from Manchester University, MS, MD and PhD in Physiology from The Ohio State University, and both clinical and postdoctoral training in Medicine and Gastroenterology at Duke University. He joined faculty at the University of Pittsburgh in 1991 where he served as Division Chief from 1999 to 2016. As a physician-scientist, his research into pancreatic disease, funded continuously for over two decades, revolutionized the field of pancreatic disorders in the areas of modeling, genetics and precision medicine – resulting in over 200 peer-reviewed scientific papers, some referenced over 1000 times, and with an h-factor of over 70. He has delivered over 500 lectures throughout the world, teaches genetics and personalized medicine at the University of Pittsburgh and is Director of the Precision Medicine for Bioengineers course at Carnegie Mellon University. He is editor-in-chief of Clinical and Translational Gastroenterology, the top ranked open access gastroenterology and hepatology journal. He served as leader of major societies, directs the annual international meeting translational meeting, PancreasFest. He founded and advanced diagnostic/information analysis and medical decision support company, ARIEL Precision Medicine. He also provides an information services on pancreas-related issues to patients, physicians, and scientist through Pancreas.org, and with a quarterly patient newsletter, Pancreas Education and Research Letter (PEaRL).

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# Work-In-Progress: "Clinical Immersion" in a Classroom Setting


## Abstract

Placing a large number of students in a clinical immersion experience can be challenging. To address this problem, we have developed three courses that "bring the clinic to the classroom." These courses are taught by clinicians who describe medical needs in their specific fields (surgery, precision medicine, and acute medical care) and then give students the opportunity to create biomedical solutions to meet these needs. These courses also include field trips to hospitals and clinics to supplement the lectures. Course evaluations and student comments have demonstrated the effectiveness of this approach.


## Introduction

It is often difficult to place large numbers of students in clinical immersion experiences due to limited physical space in clinical environments and the challenges of obtaining the required clearances and permissions. To increase the number of students who are able to participate in a clinical immersion experience, the Department of Biomedical Engineering (BME) at Carnegie Mellon University has developed three courses that bring clinicians to the classroom: Surgery for Engineers, Precision Medicine for Engineers, and Engineering in Medicine. In each of these courses, clinicians first describe medical needs specific to their fields of expertise. Students then create solutions that address these needs. Although all classes are open to all students across the university, priority enrollment is given to undergraduate majors and minors and graduate students in BME.

## Description of Classes

<u>Surgery for Engineers</u>
This course is taught by Dr. Edington (a surgeon at Allegheny General Hospital) and has been offered each year since 2009. The overall learning objective of this class is to explore the impact of engineering on surgical disciplines. Approximately 65 students each semester interact with surgeons and investigate the technological challenges that face these practitioners. Invited surgeons come from various disciplines, including cardiovascular surgery, plastic and reconstructive surgery, surgical oncology, trauma surgery, minimally invasive surgery, oral and maxillofacial surgery, bariatric surgery, thoracic surgery, and orthopedic surgery. Visits to a local hospital (Allegheny General Hospital) provide the students with hands-on experience with a number of technologies utilized by surgeons. These include microvascular surgery, robotic surgery, laparoscopic, and endoscopic techniques. Tours of the operating room and shock trauma unit are also arranged. An (optional) observation of an operative procedure was also arranged for interested students.

Students are divided into teams of four or five students, and each team identifies either a medical/surgical problem and discusses potential technologies that could improve patient care, or a specific technology and discuss ways in which that specific technology could be improved. Sample topics include needle-free diabetes care, regenerative biomaterials for cardiovascular disease, mobile sterilization for military use, and alternate methods for HIPEC (hyperthermic intraperitoneal chemotherapy).

Precision Medicine for Engineers: This course was offered for the first time in Fall 2016 by Drs. Whitcomb and Empey (clinicians at the University of Pittsburgh) to 45 students. The overall learning objectives of this class are to expose students to the basics of precision medicine, and illustrate the opportunities for engineers to develop solutions to complex medical disorders by taking into account the individual variability in genes, environment, and lifestyle of each patient. Students interact with expert physician-scientists and investigate the technological challenges that these practitioners face when treating their patients. The course focuses on eight complex disease systems: pharmacogenetics, chronic pancreatitis, inflammatory bowel disease (IBD), rheumatoid arthritis, multiple sclerosis, pain syndromes, dyslipidemia and liver diseases. The practitioners discuss how many of the disease mechanisms are similar and describe "unmet" treatment needs. This course emphasizes that improvement in the care of these conditions requires a "reverse engineering" approach and that new tools need to be developed because of the complexity and unpredictability of each disease system in individual patients.

The first half of the course introduces these eight complex systems through presentations by practitioners and patients with these diseases, while the second half focuses on tools and approaches to address unmet needs in these diseases. The course also features the opportunity for students to have their own DNA genotyped using 23andMe©. Students who participate in this optional exercise are able the analyze their own genetic data using tools presented in a genetic tools workshop that could potentially be used to individualize treatments. Those students who do not choose to have their own DNA genotyped use de-identified data for this activity.

For the team project, groups of three to five students are assigned to a disease at the beginning of the semester (e.g. rheumatoid arthritis). Each group learns about the disease, identifies one area of unmet need, designs an approach to solving the problem (with special consideration of how the patient would interface with the solution), and develops a brief marketing plan. Sample projects include a 4D MRI for hepatic venous pressure gradient measurements in patients with liver disease, a wearable sensor to monitor gait dysfunction in patients with multiple sclerosis, an innovative solution to acute pancreatitis patient care that includes a predictive model and virtual healthcare, and a novel pharmacogenetics approach that uses genetic data to create algorithms to provide customized drug dosage recommendations.

Engineering in Medicine: This course has been offered since Spring 2013 to approximately 12 students per semester by Dr. Rosenbloom (research faculty at Carnegie Mellon University and an intensive care unit physician). The overall learning objective of this class is to expose students to acute care medicine and the fundamentals of acute illness. The lectures review the structure and function of different body systems. Typical modes of failure (disease) are then described and illustrated with examples using actual de-identified cases based on over 30 years of experiences in the intensive care unit (ICU) by Dr. Rosenbloom. Field trips are made to a local

critical care and emergency medicine simulation facility at the University of Pittsburgh. An optional opportunity to participate in ICU rounds is also available.

For the class project, each student identifies an emerging biomedical engineering technology and examines how it addresses a specific aspect of acute care medicine. This includes an extensive marketing study supported by the Pittsburgh Life Sciences Greenhouse, a local resource for entrepreneurs. Sample projects include a MEMS (microelectromechanical systems) based differential viscosity sensor for the continuous sensing of interstitial fluid glucose, and *ex vivo* lung perfusion device to allow for increased functionality of potential transplant lungs, a novel technique to treat uterine fibroids, and high frequency spinal cord stimulation to treat chronic back and leg pain.

**Course Evaluations and Student Comments**

Each course was evaluated using the Faculty Course Evaluation (FCE) system developed at Carnegie Mellon University. Table 1 summarizes for clarity of the learning goals and overall course rating for each class (out of 5.0). The ratings are typically higher than the average scores for both the Department of BME and College of Engineering.

| | **Learning Goals Clearly Stated** | | | **Overall Course Rating** | | |
|---|---|---|---|---|---|---|
| **Class** | **Average Ratings for Class** | **Average Ratings for Department of BME** | **Average Ratings for College of Engineering** | **Average Ratings for Class** | **Average Ratings for Department of BME** | **Average Ratings for College of Engineering** |
| **Surgery for Engineers** | 4.60[2]<br>4.41[4]<br>4.61[5] | 4.40[7] | 4.17[7] | 4.44[2]<br>4.60[4]<br>4.70[5] | 4.10[7] | 4.08[7] |
| **Precision Medicine for Engineers** | 4.44[6] | 4.38[8]<br>4.44[9] | 4.22[8]<br>4.25[9] | 4.52[6] | 4.21[8]<br>4.35[9] | 4.10[8]<br>4.14[9] |
| **Engineering in Medicine** | 4.00[1]<br>4.00[2]<br>4.17[3] | | | 4.00[1]<br>4.20[2]<br>4.60[3] | | |

[1]Fall 2013, [2]Spring 2014, [3]Fall 2014, [4]Spring 2015, [5]Spring 2016, [6]Fall 2016 (initial offering)
[7]2013 to 2014, [8]2014 to 2015, [9]2015 to 2016

**Table 1: Summary of Course Evaluations**

Student comments also confirm the success of each course. Students in all three courses repeatedly comment that having clinicians in class gave them a better understanding of the clinical issues. In addition, the field trips to clinical sites and in class hands-on activities (such as the use of real data for genetic analysis in Precision Medicine for Engineers and assessing ICU patient results in Engineering for Medicine) gave the students a better perspective on the problems and concerns that both clinicians and patients face in different fields of medicine.

## Conclusions

We have successfully introduced three courses that provide a solution to the challenges of placing large numbers of students in clinical immersion experiences. The key to the success of each of these classes is the leadership of the clinicians in organizing the class, as well as their ability to recruit other clinicians to participate in the classes. Those who wish to implement similar courses at other institutions must engage a clinician who is passionate about working with engineering students. In the future, we plan to refine and assess the learning objectives for each course, and continue to optimize the in-class activities.

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