First-Year Seminar Course on the People of Medical Imaging

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Abstract: This first-year seminar course covers the history of modern physics using biomedical imaging as an overarching theme, focusing on both the scientists who made key discoveries and those unrecognized for their work.

First-year seminars provide a writing-intensive experience in a student's first semester of college. Undergraduate seminar courses involve discussions, reading assignments, and papers, which is much different than a typical physics course consisting of lectures, labs, problem sets, and exams. Plus, the seminar content must be accessible to any student and have no prerequisites. How does one create a discussion- and writing-intensive seminar course centered around physics? In this paper, I describe a first-year seminar which uses the history of biomedical imaging (broadly defined) to highlight the scientists who made key discoveries as well as those who were unrecognized for their work, with an emphasis on women physicists, African-American physicists, and other groups underrepresented in physics. The goal of the course is to excite students about physics, to learn about the diverse group of scientists behind discoveries relevant to medical imaging, to expose students to research-grade equipment, and to practice writing, with opportunities for revision and feedback.

Although physicists' careers involve tons of writing, we rarely have experience in teaching writing. However, writing assignments in physics courses can address student misconceptions and promote learning by requiring students to articulate their understanding of the material [1–7]. In designing a writing assignment, the expectations for the assignment must be made clear, both in terms of the subject matter and the writing style [8]. In the RAFT and TIP approach, one defines the "Task as Intriguing Problem" (TIP) and the "Role, Audience, Format, and Task" (RAFT) [1, 8], and the handout should also include a rubric clearly detailing the evaluation criteria for the assignment [8]. For a first-year seminar, there must be opportunities for feedback through multiple drafts and revision. In this course, our writing assignments consisted of in-class responses to discussion prompts as well as three major papers. The first paper asks students to describe their personal experience with medical imaging. For the second paper, students must explain a relevant physics phenomenon for a general audience, using analogies like echoes and orbits to explain ultrasound and computed tomography. The final writing assignment consists of a biography of a medical imaging scientist with an explanation of the discovery.

The topics for the course are listed in Table 1. The course begins with medical imaging, with readings from Gunderman's *X-Ray Vision* [9] and Kevles's *Naked to the Bone* [10]. We begin with an overview of the electromagnetic spectrum to put different medical imaging techniques into context. This also leads to a discussion of Elmer Imes and the relationship between spectra and quantum mechanics. A large chunk of the course is dedicated to traditional medical imaging and the corresponding physics phenomena: x-ray radiography and x-rays, nuclear medicine and radioactivity, ultrasound and sound waves, computed tomography and projections, and magnetic resonance imaging and nuclear magnetic resonance. The last part of the course is dedicated to biomedical optics. We start with our understanding of human vision and the study of optics during the Islamic Golden Age, then move to the first optical microscope followed by state-of-the-art laser-scanning microscopes and fiber endoscopes.

A large number of Nobel Prizes are related to medical imaging and the corresponding physics discoveries, and Nobel Prize controversies make for great discussion topics. Even the first Nobel Prize in Physics led to a dispute concerning Wilhelm Röntgen and Philipp Lenard [11]. Students argue whether Rosalind Franklin [12], Lise Meitner [13], William Oldendorf [14], and Raymond Damadian [15] were snubbed for the prize, while also understanding why Marie Curie [16], Donna Strickland [17], and Maria Goeppert Mayer [18] were properly awarded the prize.

The first-year seminar meets twice per week for 75 minutes each in a standard 12-week semester. Before and during class, students reflect on the reading in their writing journals. The class meeting typically consists of a brief lecture on the physics, a lab activity or demonstration, and both a small-group and open discussion on the day's reading. Lab activities and demos include a spectroscopy lab, a Crookes tube demo, a nuclear decay lab, an x-ray diffractometer demo, a TeachSpin ultrasound lab, an optical CT scanning lab [19], a lenses lab, a build-your-own microscope lab, and a demonstration of a laser-scanning confocal microscope. The ultimate demonstration involves a field trip to the radiology department at a local hospital. The course culminates in group presentations on state-of-the-art biomedical imaging techniques.

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Table 1. Medical imaging topics and people covered in the course, with each row corresponding to one 75-minute class meeting.

topic	people
electromagnetic spectrum	Elmer Imes
x-rays	Wilhelm Röntgen
radioactivity	Marie Curie
x-ray crystallography	James Watson Francis Crick Rosalind Franklin
ultrasound	Pierre Curie Paul Langevin
computed tomography	Godfrey Hounsfield Allan Cormack William Oldendorf
magnetic resonance imaging	Paul Lauterbur Peter Mansfield Raymond Damadian
nuclear physics	Lise Meitner Irène Joliot-Curie
positron emission tomography	Michel Ter-Pogossian Michael Phelps Edward Hoffman
limitations of medical imaging	
human vision	Ibn Al-Haytham
optical microscope	Robert Hooke Antonie van Leeuwenhoek
laser-scanning microscope	Donna Strickland Maria Goeppert Mayer
fiber endoscopes	Rebecca Richards-Kortum Anthony Johnson

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