Teaching Civilization, Communication Skills and Ethics through a Course in Electrical Engineering History

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Abstract

As the oldest engineering program in the United States within a liberal arts college, Union College places special emphasis on the liberal education of its engineering students. Since 1998, we have offered a course in the History of Electrical Engineering which combines study of technological development within American and European civilizations with concentration on writing, oral communication and ethics. Placing technological developments related to Electrical Engineering within a societal and human context is one way of approaching ABET's criteria for ethics (3f), communications (3g), and broad education (3h), in a course with significant technical content. In senior exit interviews, students have described the course as especially useful in developing the oral and written communication skills needed in their capstone design experience.

The course begins with the writings of Franklin and Faraday, detailing their experiments in the fundamental nature of electricity and magnetism. Wherever possible, primary source material is used, and historical controversies are explored. Students examine the methods by which "consensus" was and is reached within the scientific community and compare original expressions of theories with their modern statements. Methods of persuasive writing are explored by examining the ways in which Franklin, as an outsider, tried to have his theories accepted by the scientific establishment.

Issues of professional ethics are explored, in part, through a study of some of the patent battles that characterized early developments in radio, such as those between Edwin Armstrong and Lee De Forest. Later in the course, these issues are compared with contemporary patent battles involving the Internet and computer technology. The syllabus makes no attempt at being comprehensive, and tends to emphasize contributions to electrical technology made near the college (in Schenectady, NY) and by individuals associated with it, such as Charles Steinmetz.

The course is taught as a series of discussions motivated by student oral presentations. Each student presentation is video taped, graded by the instructor, peer-reviewed and self-evaluated. Based upon the grades given by the instructor and upon peer reviews, there is often considerable improvement in the quality of a student's presentations during the term. In several instances improvement has been dramatic.

1. Introduction

In 1998, the Electrical and Computer Engineering department at Union College began to offer an elective on the History of Electrical Engineering, motivated by both student and faculty desires to provide a wider range of ways for students to develop non-technical abilities that are essential to an engineering education. Union's engineering programs, benefiting from their presence within a liberal arts college, have traditionally required significant study of literature, civilization, and other cultures. The college's general education program also has an extensive writing across the curriculum requirement. Students requested a way to partly satisfy some of their writing and civilization requirements within the context of an engineering course, and some faculty felt that this would provide a way to focus on aspects of written and oral communication that seemed in need of improvement. The History of Electrical Engineering course that developed to fill these needs has a wide-ranging set of goals.

The course goals include:

1. To become familiar with major historical developments in electrical engineering.
2. To understand the effects of electrical technology on American and European society, and conversely, to understand the effects of these societies on the pace and style of technological innovation.
3. To improve written and oral communication skills.
4. To explore the moral and ethical consequences of invention and innovation.

2. Course Organization

Each course meeting consists of a student presentation followed by a related discussion. Students prepare for the discussion by doing assigned reading and preparing answers to a set of background questions. Weekly writing assignments relate to the discussions. Occasional mini-lectures are given to address specific points in technical writing or technology that arise in student papers and discussions during the term. Enrollment is strictly capped at 15 so that each student can make a significant contribution to classroom discussions at each class meeting. Since the class meets for 30 sixty-five minute periods over Union's 10 week term, the small enrollment also allows each student to give two oral presentations and lead two discussions during the term.

Prior to the first class, two or three pre-registered students are assigned early topics in the syllabus and are asked to be ready to present during the first week of class. The remainder of the students select their topics from a list during the first class meeting. During the first half (five weeks) of the course, each student gives a 15 to 20 minute presentation on their assigned topic. These presentations are quite general and together provide a "broad-brush" treatment of major topics in electrical engineering history, presented in more-or-less chronological order. During the second half of the term,

students meet individually with the instructor to develop a specific aspect of their topic area that will become the subject of their second class presentation, and their term-paper. For this talk, and the class discussion which follows it, they are expected to do substantial background research and to identify readings to assign to the class. Students are evaluated based upon their preparation for and participation in classroom discussions, their performance in classroom presentations, and the quality of their writing.

3. Syllabus and Technical Content

Although no attempt is made at being comprehensive, the instructor identifies a number of broad topic areas that cover the major developments in the history of electrical engineering. The number of topics equals (or exceeds) the number of students enrolled. The course text [1] and other supplemental readings provide basic background on each topic. Many of the readings are quite technical, and understanding them presents a real challenge for the students. The following list of topics was used during the most recent course offering. Several of these topics were further subdivided to fit course enrollment.

1. *Electricity:* A survey of the basic understanding of static electricity and electric current focusing on the contributions of Franklin, Faraday, Henry, and Volta. Original papers and writings by Franklin, Faraday and Henry form the basis of the unit. The different experimental and writing styles of the principles are emphasized. [4, 13, 15]

2. *Telegraphy:* The contributions of Cooke, Wheatstone, Henry, and Morse are studied. Questions such as "What does it mean to 'invent' something?" "Who 'invented' the telegraph?" "Why does one version of an invention come to dominate others?" and "What effects did telegraphy have on European and American Society?" are considered. [4, 7]

3. *Telephony:* Bell and Gray's contentions development of the telephone is used as an introduction to the American Patent system. The effect of patents on invention, inventors, companies and society is considered. [4, 5, 14, 18]

4. *Power and Light:* Edison and Westinghouse are the focus of this wide-ranging unit that includes societal issues relating to rural and urban electrification. Special emphasis is placed on the contributions of Steinmetz due to his association with Union College, General Electric, and Schenectady. [4, 8, 11, 12, 23, 25]

5. *Wireless Telegraphy:* The contributions of Maxwell, Hertz, Lodge, Marconi and Popov are used to emphasize the dependence of new invention on the work of others. [4, 17]

6. *Radio and Television:* The complex development of radio technology is used as another opportunity to study ethical behavior by inventors and by the companies for which they work. The classic patent battles among de Forest, Armstrong, and RCA are emphasized. [1, 2, 3, 4, 14]

7. *Technology of War:* The development of Radar in Germany, England, and the U.S. is used to study the ethical and public policy issues associated with military supported research and development of weapons-related technology. [9, 19]

8. *The Information Revolution:* The contributions of Claude Shannon and others are highlighted as examples of technical development that was "ahead of its time" in that its most profound influence did not occur until many years after its development. [20, 27]

9. *The Transistor and the Micro-electronics Revolution:* The development of the transistor and integrated circuits provides another opportunity to examine the effect of technology on society. [28]

10. *Computers and Computing:* The contributions of Babbage, Von Neumann and others are considered, as is the effect of computers on modern society. [10, 24, 26]

11. *Telecommunications and the Internet:* Technological and societal aspects of the "information age" are examined. [6, 24]

4. Improving Writing

The first two offerings of History of Electrical Engineering provided students with extensive feedback about their writing, but improvement in writing, based upon grades, was minimal. Subsequent offerings have made extensive use of peer-review in addition to instructor feedback, and this appears to have resulted in greater improvement in writing. This experience indicates that an effective way to improve the quality of student writing is to force students to actively consider the quality of what they and others write.

Due to a selective admissions policy, most Union College students have good basic writing skills, but they often need help in developing a clear, concise and precise technical style, and in organizing their thoughts and ideas around establishing a thesis. To accomplish this, each student paper is peer-reviewed by another student prior to it being turned in. The peer-review uses a form that focuses first on overall organization, then on paragraph structure, and finally on grammatical issues and sentence structure. The peer-review itself is graded with regard to its thoughtfulness and how helpful it is to the paper author. The instructor identifies several writing issues that a number of

students are struggling with, and displays examples of student writing in class (without author identification). The entire class then plays "editor" and attempts to improve the writing sample. Typical issues are clarity and brevity of expression, or paragraph organization. Later, without notice, students are required to use the peer review form on their own first draft, and then to modify their paper accordingly. Since the course is not taught by an instructor with any formal training in writing instruction, the most important skill that students take away from the course is the ability to critique their own writing.

5. Improving Oral Communications

Most students have had only limited experience with giving oral presentations. The strategy used to improve their presentations parallels that used on their writing: required self-reflection. Each student gives an initial presentation early in the term. This presentation is peer-reviewed by each member of the class, using a form provided, and is reviewed and graded by the instructor. Most importantly, the presentation is video-taped, and the student is provided a copy of the VHS tape to watch in private. After watching their tape, students fill out their own self-review form, and are then given the reviews from the class and the instructor. Armed with all of this feedback, each student writes a one page "plan for improvement" used in preparing their second presentation. Their grade on their second presentation largely reflects the degree to which they improved in areas identified on their plan. The second presentation is also video-taped and peer-reviewed, and each student hands in a one page self-critique.

One of the most rewarding aspects of teaching this course has been to watch the significant, and sometimes astounding, improvement that occurs in the quality of student presentations during the term. It is not uncommon to see students who get C's or D's on early presentations receive A's or B's on later presentations. This improvement is often carried over into grades on presentations that they give during their capstone design experience.

6. Understanding Ethics in the Context of Invention

There is no formal treatment of engineering ethics in the course, but ethical issues permeate most topics in the syllabus. Students are routinely asked to reflect on the degree to which they consider the actions and behavior of inventors and companies to be "just" or "unjust," "moral" or "immoral," "legal", or "illegal." Appropriate standards for behavior for an inventor and a company are discussed, as are issues such as priority of invention and plagiarism. Patent and copyright battles are used as a running theme in order to engage students in making judgments on how to best assign credit and benefit for an invention or creation.

Students are asked to reflect on the effects of technology on society and on the degree to which inventors bear responsibility for the eventual use of their inventions. As

with writing and oral presentation, a goal of the course is to require students to consider moral and ethical issues when examining the past, and to show them that similar issues confront the present.

7. Conclusions

The History of Electrical Engineering course has many goals, all of which jockey for time and emphasis in a short 10 week term. While, in a sense, no one area receives its just due, the combination of focusing on technical developments, technology and society, writing, speaking, and ethics has provided students with an opportunity for growth in a number of areas important to their education as engineers. A course on the History of Electrical Engineering is probably not central enough to most programs to justify being required, but provides sufficient value to students to be recommended as an elective.

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