Teaching Technology in an Honors Program – A Model

By Roland Heck

Roland Heck, a chemical engineer with a 32-year career in industrial research and engineering in the energy industry opted to take early retirement and move to academia in 2000. He secured a position at Princeton University as Associate Dean for Engineering and Applied Science and participated for six years in the teaching of a course entitled *Engineering in the Modern World*. This course had been developed by Professor David Billington in the mid-1980's to introduce engineering concepts to liberal arts students. (See Princeton Case Study in this collection.) In 2008, Heck decided to shed his administrative duties and teach his own version of the Billington course at his *alma mater*, the University of Delaware. With the urging of Delaware's Dean of Engineering, Heck developed a technology based first-year colloquium *Technology in America* for their honors program.

Heck decided to name the honors colloquium *Technology in America* both because not all the technology he planned to cover was strictly engineering, and because he did not want liberal arts students to shy away from an "engineering" course.

Course Structure/Requirements and How They Were Met

Courses in Delaware's Honors Program are characterized as intensive reading and writing courses. So, students are not expected to solve engineering problems. In Heck's colloquium the writing and presentation assignments always required some discussion of technical issues, but no problem sets. Rather, issues in the realm of economic, environmental, political and societal were given more weight. Honors colloquia at Delaware are held to a maximum class size of 22. Heck's course always filled soon after registration opened.

In the first year of the course, David Billington's book, *The Innovators*, was used as a text, but since much of the book involves engineering problem solving, it was decided go in a different direction in subsequent years. Professor Heck scoured the web and was able to find enough suitable articles to assign in subsequent years.

Class time during the first half of the semester concentrated on 18th and 19th century innovators and the foundations of technology, but readings and discussions also included current issues within the subset of those technologies. A list of Lecture Titles and Potential Discussion Topics is given in Table 1. The second half of the course, tended to feature four or five industrial or academic guest lecturers in preparation for which students were assigned to read articles on the guest speaker's topic and *to develop questions* that would be emailed to the speakers before their visit.

Requirements

Two short papers on historical topics would be assigned early in the semester, one of which was to be historical fiction where the students were asked to assume a designated role in a historical setting. Class participation made up only a small part of the course grade. More important was the term paper on a currently evolving technology. Students selected term paper topics early (from a list of 22 suggested topics) giving them most of the semester to research their topic. Or, with guidance, they could, instead, suggest their own.

The University of Delaware's Honors Program provides two student writing fellows for each honors colloquium. Heck asked for both to enable his enrollees to go over a draft of their essays and term paper with the writing fellows about a week before the final work was due. Noteworthy is that students' drafts were not to be rough outlines, but actual full-length versions of the paper. Another feature of the writing assignment was that the students' drafts would be handed in along with their final papers, enabling comparisons and further learning from the experience.

In addition to the written assignments, students were asked to make two presentations. The first, a six-minute talk on a topic related to the lecture of the day, the second, a short description on their term paper that was delivered in one of the last few classes of the semester.

Readings were assigned for each class and email responses to questions on these readings were usually due the evening before class. These emails gave evidence of student understanding and provided a basis for class discussions.

Lecture topics, themes and potential discussion topics are given in **Table 1.**

Writing Assignments

The first writing assignment dealt with the industrial revolution, which most historians agree began in England during the 18th century. An internet search reveals at least 25 different political or social antecedents associated with the industrial revolution: the rise of capitalism, the end of feudalism, the Enlightenment, the agricultural revolution, abundant iron and coal, the Protestant work ethic, the rise of the middle class, migration to the cities, a strong patent system and a shortage of wood. Students were each assigned one of these phenomena and asked to assess its role in the early years of the industrial revolution. It was explained by the instructor that any phenomenon could be a *cause* or an *effect* or simply *coincident* with the onset of the industrial revolution. After the class discussion, each student was asked to compose a short essay on the three primary reasons for the industrial revolution starting when it did, where it did.

Another early essay assignment had to do with the U.S. patent system. A search of the web for "problems with the US patent system" results in more than 22 million hits. The students were asked to read at least 10 of these web articles and then write an essay using three as the basis of their analysis.

The second major writing assignment usually had to do with 19th century technology.

Two important 19th century expositions where American technology was showcased were the Centennial held in Philadelphia in 1876 and the Columbian Exposition held in Chicago in 1893. Students were tasked to assume the role of a European journalist writing an article on one of the two for a European newspaper. In addition to the short papers, students were responsible for choosing, drafting, and finalizing a major term paper.

Term Paper Topics

Early in the semester each time the course was taught, students were asked to select their term paper topic from a list (**Table 2**). Alternatively, they could request approval for a term topic of their own choosing (usually one student per semester). Most important for beginning writers about technology, all had to provide one-page status reports on their term papers before submission of the draft.

Guest Lectures

In the second half of the semester four or five guest lecturers would be invited to speak with the class, at least three from industries within driving range of campus; the other two, university professors, one from Princeton and the other from the University of Delaware. The students were assigned web reading having to do with each speaker's topic and asked to develop and (most important) hand in questions for the speaker a few days before the lecture.

Industrial speakers included:

- Exelon Corporation, Vice President Exelon Nuclear
- Exxon Mobil Research and Engineering, Manager for Technology Evaluation
- DuPont Company, Worldwide Manager for Solar Solutions
- US DOE, Technical Director for Carbon Capture Simulation Initiative
- W.L. Gore & Associates, Manager of Capabilities Center
- Mobil Solar, President

Course Acceptance

As mentioned earlier, the maximum class size is 22 in the Delaware's Honors Program. Yet, despite the newness of the topic in that environment, classes invariably filled the first day of sign-up and attendance remained nearly to 100% for most classes. Student course evaluations were largely positive and for many students each semester *Technology in America* was their favorite first-year course. The students particularly enjoyed having a chance to dialogue with guest speakers and becoming an "expert" on their paper topic. Students always wanted more class discussion.

Engineering Concepts Introduced

The course was organized around the four traditional engineering disciplines: civil, mechanical, electrical and chemical. But what made it different from a traditional course was that basic engineering principles that are the foundations of these disciplines were discussed only in the context of their historical applications.

Examples:

Eighteenth century iron bridges were one of the first applications of civil engineering. To expand upon this example, the course included an analysis of the balance of forces in the early truss and suspension bridges.

The best example of early mechanical engineering is Watt's steam engine, which increased the efficiency of fossil fuel conversion to work by a factor of four (to about 2% efficiency). The course tracked the further improvement to about 60% efficiency in today's combined cycle gas turbine engines.

An early application of electrical engineering was the telegraph. Thomas Edison, an early telegrapher, expanded the application of electricity to the light bulb as a means of power generation and transmission to make the light bulb practical. In the end, his DC system lost out to Tesla's AC system and for good reason. The logic and science behind this historic AC/DC battle are presented.

Chemical engineering was born with the onset of the petroleum industry that was built on the efforts of engineers to efficiently refine petroleum into high yield quality transportation fuels.

Nuclear power relies on all four engineering disciplines. The students learn about the science and engineering behind nuclear power and the missteps that led to the world's three principal nuclear accidents: Three Mile Island, Chernobyl and Fukushima. They also learn how prudent design and operation of these facilities could have prevented each of these.

Student Outcomes

Since there were no quizzes or exams on course content, students' mastery of the material was hard to measure *in any specificity*. The purpose of the course was to give students a general understanding of the technological innovations that undergird modern society. They also were exposed to the economic, environmental, political and societal issues surrounding these innovations and to the individuals who brought them into being. That there were significant gaps in students' general knowledge, was made clear when Heck inquired informally

at the outset of the course, how many were able to identify James Watt, Robert Fulton or John Roebling or even Werner von Braun.

Additional Skills Imparted

Although all students in the course had been accepted into the University of Delaware's Honors Program, their ability to express themselves in essays and presentations ranged from "excellent" to merely "fair." Most hadn't yet learned the differences among creative, informative, and expository writing. Initial papers had to be purged of long and complex sentences and extraneous words and phrases. In his advisory to students by way of comments on their papers, Heck drew on his own resources: the KISS theory of good writing (http://www.writeenglish.org/improve-english-writing/write-simple-straightforward-manner) and Robert S. Burger's book, "How to Write so People Can Understand You."

He also illustrated and critiqued students' power-point presentations.

Following are examples of daily assignments

Daily Reading/Email Assignments: Examples

Read:

"The Man Who Made Cotton King",(http://www.inventionandtech.com/content/man-who-made-cotton-king-0)

Be prepared to discuss in class:

- Why didn't Eli Whitney benefit financially from his cotton gin patent?
- Why do some people say that the cotton gin led to the Civil War?
- "The Man who made Cotton King",(http://www.inventionandtech.com/content/man-who-made-cotton-king-0)

Read

- http://www.nei.org/corporatesite/media/filefolder/top_10_reasons_to_support_.nuclear.pdf
- Top Ten Reasons Nuclear Power Is Vital To America's Energy Policy
- http://www.nirs.org/nukerelapse/background/toptenreasons.htm
- Top 11 Reasons to Oppose Nuclear Power
- The Economist: Half Death: The future of nuclear energy, Oct. 31, 2015

Write a short email expressing your opinion on building more nuclear power plants.

TABLE 1

Lecture	**Discussion Topic**
Introduction/Overview	Course Expectations
Darby, Watt, Telford & the Industrial Revolution	Iron, Steam and Engineers
Fulton and River Highways	Regulation of Technology
Jefferson, Hamilton, Whitney & Lowell	Agriculture and Early Manufacturing
Henry/Morse & Telegraph	Who really invented the Telegraph?
Carnegie & Affordable Steel	The Steel Industry Today
Edison, Tesla & Bell	Breaking up Bell Telephone
Rockefeller and Oil Refining	Fracking and the Oil Glut
Ford, Sloan & Automobiles	Growth and Decline of Unions
Suspension Bridges	Rail versus Canals & Highways
Wright's Flyer & Langley's Aerodrome	Controlling Flight
TVA & Western Dams	Public versus Private Ownership
Radio: Hertz to Armstrong*	Impact of Mass Communication
DuPont Corporation Today*	200 Years of Corporate Evolution
Jets/Rockets & NASA	Making the World/Universe Smaller
The Future of Oil*	Oil and Gas are High Tech
Curie, Einstein & Nuclear Power	Safe, Clean, Energy for the Future?
The Transistor and Computers	Information Technology & The Internet
Power Generation in America*	Coal, Oil, Solar, Wind and Our Aging Power Grid
Term Paper Presentations (5 or 6 classes)	
4 Per Class Period	4 Designated Student Questioners

*Guest speakers from Industry

TABLE 2

Term Paper Topics

Geothermal Energy	Air Quality
Artificial Intelligence	Wireless Technology
Biotechnology for Health	Future of NASA
Biotechnology for Food	Nuclear Fusion
Google Glass	Nanotechnology
Fracking for Natural Gas	Future of Coal
Future of Nuclear Fission	Hydropower
World Water Supply	Tidal Power
3D Printing	Wind Energy
Electric Cars	Future of the Transistor
Hybrid Cars	The End of Oil
Autonomous Cars	The Future of Computing
Thermal Solar Energy	The Future of Apple
Photovoltaics	Combating Climate Change