AC 2008-2140: TEACHING ASPECTS OF TECHNOLOGICAL LITERACY FROM A HISTORICAL PERSPECTIVE

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Teaching Aspects of Technological Literacy From a Historical Perspective

Abstract

While technological literacy is a topic of special interest to engineering educators, the subject is not limited just to areas of knowledge familiar to engineers. To cover the relevant issues requires knowledge not only of technology, engineering practice, and selected topics from science, but also from business, economics, and the social sciences.

History provides an abundance of examples of technological innovations and their impact on society. Case studies based on these examples can be used to teach aspects of technological literacy. The ideal person to develop historical case studies is both an engineer and a historian. It is rare to find one person who is qualified academically in both fields. If such an individual is not available, then there is the option of forming an instructional team consisting of a historian and an engineer. Working together, this team can present both technological and historical aspects of different technological innovations.

Several years ago, the authors had the pleasure of working as an instructional team to teach a special course in the history of technology. The authors found the experience of team teaching to be both enjoyable and rewarding, and hope that this paper will encourage others to try a similar arrangement. This paper will discuss the course as taught and lessons learned. It will discuss roles for the historian and the engineer in the course, and explore options for enlarging the instructional team to include members from other fields. The paper will also examine administrative issues involved in assigning two instructors to a single course.

The paper will give special emphasis to the historian's perspective on engineering and technology. To fully appreciate technology, one must understand its impact on society and the economy. The historian who specialized in economic history has a valuable perspective on the impact of technological change on society. Historians who specialize in other fields can point to cases where a technological innovation was a critical element in the course of history. The paper will also explore areas where the engineer's ability to understand how technology works is needed, and how the expertise of the engineer and the historian can complement each other.

Introduction

In the National Academy of Engineering (NAE) publication "Technically Speaking," technological literacy is described as giving people the knowledge necessary to understand, think critically about, and make informed decisions about technology.[1] The report describes this as having the dimensions of knowledge, ways of thinking and acting, and capabilities. In this description, knowledge includes understanding of how a technology comes into being and the conditions necessary for its development and how technology changes people's lives and how humans affect the development of technology. Ways of thinking and acting include helping people learn how to participate intelligently and effectively in making decisions as a community about technology.[2]

In addition to the NAE report, technological literacy has been the subject of a National Science Foundation (NSF) report[3] and of papers presented at a series of American Society for Engineering Education (ASEE) conference sessions. In one paper, Ollis and Pearson discuss technological literacy, and note that it is "hard to imagine any single person, even an engineer, possessing all of the traits associated with technological literacy."[4] Many institutions have offered courses to help students develop technological literacy; in one paper from 2006, Krupczak and Ollis review twelve such courses.[5]Their review shows many different approaches to teaching the subject. Ollis has been successful with courses that include device dissection.[6] Carlson recommends an approach based on case studies from the history of technology.[7]A more thorough review of this literature is given by one of the authors in (8).

As noted by Carlson, many facets of technological literacy can be explored through case studies from the history of technology. Historical examples can show the development of a new technology, how a new technology can affect the lives of people, and how people make decisions that affect, or can stop, technological change. While a course focused on the history of technology will not cover all aspects of technological literacy, it can cover many pertinent aspects and can make a significant contribution to the technological literacy of people who participate in such a course.

Teaching a Course in the History of Technology

In the spring of 1998, one of the authors, a professor of history, was contemplating offering a course on the history of technology for students in the university's honors program. The vision for the course included a team of instructors and guest lectures from faculty members across the university. The historian wanted to find a partner to serve as a second principal instructor. Given the material, it made sense to find someone with an engineering background. The other author, a professor in the engineering technology department, had a strong interest in this area, and agreed to be the second principal instructor.

The honors program gave faculty a unique opportunity to explore new courses. The university bulletin described the program in terms of "interdisciplinary courses … team taught by professors from a variety of disciplines … in small classes."[9] Students who applied for and were accepted into this program had to meet high academic standards. With students in the program being required to take honors courses, there was reasonable assurance for the instructors that the course would attract sufficient enrollment. For the program, the course would be offered as an upper level course for junior and senior students.

The course was offered in the fall of 1999. Due to changes in the honors program and in policies regarding assignment of two instructors to one course, the authors have not been able to date to build on the success of this initial effort.

Course Focus and Content

While the goals of this course could be met by looking at any period in history, the authors chose to focus primarily on the period from the Industrial Revolution to the present, and explored the development of 19th and 20th century technology and American inventions and innovations. The

university core requirements include two courses in American history, and the focus on developments in the United States let students to build on this foundation.

In the planning stages for the course, the authors discussed and selected specific topics for presentation. Lecture topics presented by the authors included

- Machinery in the First Industrial Revolution,
- Resistance to Technology: Luddites, Child Labor,
- the Early American Industrial Revolution,
- the American System of Machine Tools,
- the Brooklyn Bridge,
- the Steam Engine: Revolution in Power,
- the Steam Engine in Transportation – Railroads,
- the Age of Electricity – Telegraph, Telephone, Edison,
- Technology on Display: World's Fairs,
- Taylor, Ford, and Mass Production,
- Human Flight: Development of Aircraft, and
- Technocracy and the Rule of the Engineer.

Each author then took responsibility for certain topics. The history professor took responsibility for the evolution of manufacturing for mass production, bridges and structures culminating in the Brooklyn Bridge, Ford and Taylor, and for celebrations of technology and progress in world's fairs. The engineering technology professor took responsibility for transportation in general, steam engines, and for aircraft. He also lectured on the engineering profession and the relationship between engineering, science, and technology.

Both instructors gave introductory lectures to set the stage for the course. The engineering technology professor gave a broad overview of technology from ancient times, and the history professor focused on important issues in the historical study of technology. Similar discussions are found in books by the engineering professor David Billington[10] and the historian David Nye,[11] among others. A discussion of Leonardo da Vinci was used as a bridge to the modern era, and then the course moved on to the Industrial Revolution and then to developments in America.

Lectures by the primary instructors were interspersed with presentations by guest lecturers. The topics included

- Technology in the Ancient World,
- Technology of Materials: Steel,
- Technology of War,
- Representations of Technology,
- Technology Managed: Swedish Social Democracy,
- Technology of War: the Atomic Genie,
- History of the Computer, and
- History of the Internet.

This allowed us to bring a wide range of expertise into the course. For example, a professor in classical studies discussed technological developments in the Greek world. Another history professor who specializes in military and naval history spoke on the technology of war, while a physics professor spoke on atomic bombs. A colleague with a special interest in early automobiles and road building spoke on these subjects. An art professor talked about

representation of technology in art. Information technology was discussed by a professor from the School of Education who specializes in instructional technology. An international perspective was added by a visiting professor from Sweden. Each of the guests made a valuable addition to the course content with their unique perspective and made the course more interesting.

Some of the lectures were augmented with artifacts. An early American brass clock was used to show students the mechanism and demonstrate the escapement. An early sewing machine was shown to demonstrate the complexity of the device. An Edison phonograph was shown, as well as a radio from the 1930s. These artifacts gave students a visual reference and the opportunity to see how these devices work.

While the guest lectures brought additional dimensions to the course, most of the course was presented by the primary instructors. The topics were organized such that one instructor would be responsible for several consecutive class meetings, and then the other instructor would take over for a similar number of classes. This gave each instructor time to work on material without having to immediately present the material at the next class meeting. In general, each instructor stuck to their assigned material, rather than having both instructors present material on different aspects of the same topic.

Student were assigned readings from several books, including Cowan, A Social History of American Technology,[12] Smith and Gregory, Major Problems in the History of American Technology,[13] Petroski, Invention by Design,[14] and Bellamy, Looking Backward.[15] Cowan's text covered the overall period, Smith and Gregory, and Petroski were used for specific topics. Bellamy's landmark work of fiction was used to explore technological change and was the basis for a major course assignment. Additional readings were assigned from reserve material, and students were expected to use other library resources.

In addition to written sources, students viewed the movie Metropolis (1927). Bellamy's book gave an optimistic view of a future technological wonderland, where technology is a tool used to create a moral universe. As a counterpoint, the movie offers a horrifying view of technology as an agent of oppression and destruction.

Outside of the classroom, the course included a visit to a nearby private museum with an extensive collection of tools and a trip to the nearby Saturn automobile plant.

Assessment followed the standard pattern of history courses. Students were required to take midterm and final examinations with essay questions. They were also required to complete two papers, an analysis of one of the assigned texts (Bellamy) and a research paper. Both instructors evaluated all of the work and then reached a consensus on final grades.

Students were offered three options for research paper topics. The first option required them to trace the development of a specific technology over time as recorded in the Scientific American. This publication, going back to 1845, was available in the university library on microfilm. The second option focused on World's Fairs as showcases for the technology of the future, and

students could examine one of these fairs to explore its vision of technology and the reaction of the visitors. Finally, students could select a specific form of technology and explore its impact.

The examination questions demonstrate the goals of the course. These questions asked students to explore the development of specific technologies, ranging from the spinning jenny to the airplane, and their effects, both positive and negative. Students were asked to look at the development of technology, and one question asked students to contrast the idea of the heroic lone inventor with the actual process of development.

Students

The course attracted a reasonable number of students. The majority of the class fit into two groups of roughly equal size, one of history majors and the other from the honors program. A few engineering technology majors, who used this class as an alternative to our introductory course for first semester students, were also in the course. The honors students were drawn from majors across the university, and this diversity of backgrounds was unique for upper division classes and, for the instructors, an enjoyable feature of the course.

The students seemed to find the material interesting and enjoyable. Students had the opportunity to choose their term paper topics, and their choices gave evidence that the students were able to relate the material to their own areas of interest. In one example, a student majoring in music proposed the early electronic musical instrument, the theremin, as the topic for the paper. The paper was well done, and brought together for that student their area of interest and the study of technology.

Teaching Technological Literacy through the History of Technology

The material presented in the course fits well with two of the three dimensions of technological literacy. Other than requiring the basic use of information technology tools for finding and processing information, a history of technology course is unlikely to adapt well to teaching capabilities. However, the material is admirably suited for teaching the dimensions of knowledge and ways of thinking and acting. Case studies from history are well suited to showing how technology is developed. These examples show the role of individuals, organizations, and governments in developing technology, and show the wide range of possible paths for technological development. Case studies from history can show both why the concept of technological determinism is popular and how, despite perceptions, people can and do exert control over the process of technological development. While case studies from any era can be used, examples from the recent past will give students insight into current patterns for technological change, and hopefully give students insight into the near future as well.

While teaching the history, one can also teach about how certain technologies work at a basic level. In the process, one can explore both the scientific principles that explain why something works and also the arbitrary decisions made by people in the design and development process. The concept of technological momentum can be explored through discussion of standard components, for example, and students can be shown how, once a standard is established, this can constrain development.

Finally, ways of thinking and acting includes helping people learn how to participate effectively in making decisions as a community about technology. Again, case studies can demonstrate how people have been effective in controlling or even stopping a technological project or development that seemed to the technological determinist to be unstoppable. Also, the course can give examples where societal concerns hindered development of a desirable technology.

To adapt the course to focus on technological literacy, topics for in-depth discussion should be selected to focus on specific aspects of technological literacy. One option is for the overview section to be extended to reach the present, and then certain topics would be singled out for more attention. The technology of pesticides, notably DDT, could be used as a case study of an initially accepted technological development that was later abandoned when people realized that the chemical had unintended and destructive effects on the environment and enough people pushed for change. Nuclear power generation technology would be another good example for exploring issues between people and technology. Care needs to be taken to ensure that students get the broad picture of the history of technology while also considering specific issues from technological literacy.

Another option for adapting this course to teaching technological literacy would be to add more material about the forms of technology being discussed in the historical context. This effort could include physical demonstrations and other exercises that would help the students grasp the technological issues being discussed. While the primary delivery mode is likely to be the lecture format, some class time spent doing something other than lecture is likely to make the course more attractive to students.

This course was taken primarily by people who were not majoring in the engineering area. Both authors would note that the study of the material covered in the course would be useful to engineering students. This holds whether the course is taught in its original lecture format or if it is modified to better support the goal of developing technological literacy through additions such as demonstrations and laboratory exercises.

Lessons from the Course

In this initial offering, the authors each took on different topics. An alternative that appeals to the engineering author would be to have each instructor discuss the same topic, with each playing to their own strengths. When this course was offered, the engineering technology professor had the task of talking about railroads. In this discussion, the first transcontinental railroad merited attention, and this is a topic that would interest both an engineer and a historian who was interested in teaching such a course. It fits the background of an engineer to focus on the technological aspects. An engineer can also discuss economic and social issues, which takes the engineer into the historian's area of expertise. While the engineer can develop expertise in this area, it would be wise to have a professor with credentials in history who already has expertise in that area address issues such as the financial and political scandals associated with the transcontinental railroads and their construction companies.

As the historian should take the lead in some areas, the person with engineering knowledge should look to support the historian on technological aspects. The engineer's background prepares them to address technology, engineering, and the science involved in the engineering work. For example, in our division of topics, the historian took on the development of large scale manufacturing. In doing the course again, the engineering author would want to present material, ideally including demonstrations of machine tools and manufacturing processes, designed to augment the historian's presentation. Having worked through this course once as a team, the authors would be better prepared to work together on the same topics and to recognize where each could best help the other.

In an ideal division of labor, a historian with an interest in economic history would focus on economic and social aspects, and put the topic in the broader context of society at the time. For the history professor, this may be a chance to talk in more depth about areas of interest that can only be discussed briefly in other courses. For example, the author from the history department teaches American history courses which are a required part of the general education core. The core courses allow the professor to present the basics, but do not allow much opportunity to go into details. The history of technology course allows one to spend more time on these topics, which can be an opportunity to teach in one's own area of interest.

With the history professor taking the lead on economic and social issues, the engineer would be able to focus on the technology – how it works, what people had to do to make it work, and why the people made decisions as they did when creating the technology. The engineer is prepared to discuss limitations, such as constraints imposed by the load capacity of materials available at a given time or by other factors. The engineer should be prepared to discuss arbitrary decisions made in the design process, and how a once arbitrary decision can become an accepted standard, and how in turn those standards can become limits for later designs. The engineer should discuss how time and money constraints affect the development of a technology, and how getting something done within these constraints pushes the designer to an acceptable result that works but may have significant room for improvement. For a professor who is accustomed to teaching engineering analysis courses such as thermodynamics or machine component design, this is a significant shift from teaching how to analyze something given in detail to how we get to that something to be analyzed, and is similar to the shift necessary to go from analysis to design courses. Also, it is a departure from the standard compartments of engineering analysis courses to teaching about a specific technology, such as railroads or aircraft. Having the engineering instructor focus more on these aspects would contribute to developing the technological literacy of the students. This could also lead to some hands-on exercises that would give students greater insight into aspects of technology as well as being enjoyable for the students.

The authors note that, while a division of primary responsibility is ideal, the two instructors must not work in isolation. The person with engineering expertise needs to have a degree of knowledge about social and economic issues, and the historian needs to know something about the technology. With the instructional team approach, each has an expert in the other field to turn to for help in developing their own knowledge. Course development should be an iterative process, where the instructors review the assignments of topics or aspects of the same topic, and revise the plan for presentation and division of labor. Both should look for opportunities to use their expertise to support each other, and should be open to passing topics to the other instructor.

Teaching such a course has its rewards. The authors of Technically Speaking note that, while engineers are trained in specific areas of technology (capabilities), often engineers need to learn more about the other areas of technological literacy.[16] Preparation for this course gave the engineering author a better understanding of these other aspects and a better perspective for teaching engineering subjects. For the engineering author, this experience brought an important element of understanding of engineering and technology that had not come directly from his engineering education, which made this a very positive experience.

Challenges

This course was offered under an honors program which emphasized team-based instruction. The team based approach worked very well with this course. There are historians, such as Merritt Roe Smith, Thomas Hughes, David Nye, and Ruth Schwartz Cowen, who are recognized for their expertise in the history of technology. Likewise, there are engineering professors who have been recognized for their writings in this area, such as Henry Petroski, David Billington, and John Landis. While an engineer or a historian can work in this area and develop a course on their own, it is a significant challenge to develop knowledge and expertise in both engineering and history. The structure of the academic environment does not allow professors much opportunity to stray beyond the boundaries of their own field. For those interested in developing a course addressing technological literacy though the history of technology and who are limited in the time that they can devote to this effort, the authors recommend that this be approached as a multidisciplinary project with a team of instructors. With this arrangement, one person does not have to do it all, as each member of the team has already developed expertise in their own area.

A critical issue for this course in particular and team-based, multidisciplinary instruction in general is institutional support. The institution must be receptive to and supportive of efforts by faculty from different disciplines to come together to work on an innovative single course. The institution must have a mechanism to allow two instructors to be assigned to the same course. The institution must have a mechanism to allow for guest lecturers, and to compensate these guests for their effort. The instructors and the students must have access through the university library, either on-site or electronically, to reference materials. Visual aides, both still images and videos, are needed to teach this subject. The instructors must have support in preparing materials, equipment such as scanners and classroom projection systems, and general support with instructional technology.

The instructional team approach is not a common arrangement at universities. When this course was first offered, we had this option through the university's honors program. After this offering, there was a change in administration. Reflecting general trends in state supported higher education, the new administration focused on increasing efficiency and maximizing enrollment. Instructors had to be used as efficiently as possible, and innovations such as team-based instruction had to be abandoned. The authors regret that they were not able to make a successful argument in this environment to continue with this sort of arrangement. The authors would argue against an arrangement that, while allowing for an instructional team, would only credit each instructor with one part of a course for their teaching load. While neither instructor was required to develop and present all of the material, there are additional time demands on

each member of the instructional team, and we found that the work load necessary to coordinate instruction, grading, etc., was equivalent to teaching a regular course for each instructor. For a team-based course to be attractive to prospective instructors and to fairly compensate instructors for their work, this needs to be counted as a full course for each instructor.

While institutional considerations support the traditional single instructor arrangement, we would argue that, for such a multidisciplinary course, it is valuable not only to have an instructional team but to expand the team with guest lecturers and, possibly, faculty from areas of interest who would have greater involvement. Both authors recommend having other professors come in and give guest lectures in their areas of expertise. These guests must be offered some compensation from the institution for their efforts. If possible, more involvement than would be expected from guest lecturers would be welcome from faculty with expertise in areas such as sociology, economics, or business. In expanding the team, it is doubtful that all of the instructors could have an equal role. Another model for inclusion would be needed for instructors who would be more involved than a guest lecturer, but less than one of the primary instructors.

While the authors would be pleased to have been able to establish this one semester course on a regular basis, it could be expanded to, at least, a two course sequence. If more members were added to the instructional team, it is unlikely that all instructors could have sufficient time in a single course. With two courses, one course could focus on the history of technology, and the companion course could include other aspects of technological literacy. For example, a second course could include a technology dissection lab, such as those offered by Ollis,[6] or a design project. To do this, one must attract enough students who would need these courses in their degree program and must keep their interest for the course sequence. Some capstone experience that would be both educational and enjoyable should be reserved for the second course to encourage students to complete the full sequence.

Going beyond the regular courses, this sequence could be linked to a summer program with travel. One useful option would be a visit to museums and industrial archaeology sites in the United States or abroad. At one point, one of the authors attempted to arrange such a program for students to go to Britain and visit sites from the Industrial Revolution. For a general effort in technological literacy, another useful option would be to expand beyond plant visits in the region to visiting modern industrial sites in other countries. At our institution, one professor in our engineering technology department has developed a relationship with a university in Taiwan. A program to take students to Taiwan would fit this partnership and would fit nicely with efforts to teach technological literacy. Again, institutional support is vital for such a program.

Conclusions

The authors, one from the history department and the other from engineering technology, worked together to teach a course in the history of technology. The course as offered met many of the goals set for helping students develop technological literacy. For both authors, this was a challenging, and also enjoyable, experience. Given the multidisciplinary nature of the material, the authors both recommend that more than one instructor be assigned to the course. With the necessary institutional support, such a course can be developed that will interest students and help them to develop technological literacy.

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