AC 2007-1022: INTEGRATING TECHNOLOGY: OUR CULTURE, OUR STUDENTS

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Integrating Technology: Our Culture, Our Students

Introduction

For those of us who have had the opportunity to teach both the technical and non-technical students within a university environment, it is clear that a divide exists between many of the students who comprise these groups. How often have we heard students make statements that characterize themselves as either interested in social issues or technical ones, as if there is no overlap between the two realms? Technology, using either a broad or narrow definition, is so pervasive within society and culture that we cannot complacently accept polarized positions. As engineering and technology educators, we must address the issue, and we must recognize that there are *two* sides that need to be addressed: providing appropriate content that encourages students of the arts and social sciences to become fluent with the language and function of technology and providing appropriate content that encourages students of science, engineering and technology to become fluent with the language and applicability of traditionally liberal education studies.

Technology Literacy. In the wake of rapidly advancing technology, agendas for technology education are prevalent. The Committee on Technology Literacy, consisting of experts from diverse subject areas and organized by the National Academy of Engineering and the National Research Council, published a report in 2002. This report broadly defines technology as comprising "the entire system of people, organizations, knowledge, processes, and devices that go into creating and operating technological artifacts as well as the artifacts themselves."[1] The report documents that people today eagerly participate in new technologies through their role as consumer; however, they often have less of the hands-on experience which led prior generations to a certain level of intuition about how the technology worked. Today we have many individuals who can use various technologies in fairly sophisticated ways, but they do not know enough to tinker, alter or repair. They also do not know enough about the technologies to think critically about them in the context of their impact on society and culture. The report calls for educators to embrace this problem and take action to develop greater levels of technological literacy for the world's citizens. But what constitutes technological literacy?

A 2006 report defines technology literacy as the ability to use, manage, evaluate, and understand technology.[2] The report further notes that today's technological systems have become intertwined with social systems unlike any previous time in history. Any advances or changes in technology have far-reaching effects socially, culturally, and scientifically. How people develop and apply technology today has become critical to future generations and future society, even to the point of compromising the Earth's ability to continue to sustain life. The definition of technology literacy in this report (and others), has two aspects. One is that everyone needs a deeper understanding of the scientific and/or mathematical underpinnings of various technologies and the other is that everyone needs to understand the context of how, where, and when the technology is applied and be able to analyze what the impacts might be.

Thus, a goal of technology literacy for university-educated adults must be targeted from two fronts. One is to enrich the curricula of student engineers and technologists so that they understand the society and culture in which they develop and apply technology. The second, is to create curricular elements for student sociologists, artists, and historians (for example) to bolster their scientific and technical knowledge so they can make sound decisions regarding using technology in the world in which they live. In both cases, the challenge is providing sufficient depth of content for meaning without creating a chain of prerequisites that burdens degree programs with an additional semester of study.

Liberal Education. Engineering and technology educators, in general, understand technology and are prepared to deliver technical content to students. However, some may be concerned about what it means to provide the context for application of technology.[3] If we turn to the literature related to cultural literacy and liberal education for this, we see liberal education described as an approach that goes beyond content areas to encompass and embrace a way of viewing and interacting in our world. In fact, Berkowitz describes liberal education as not an alternative for specialization but rather a "preparation for specialization." Liberal education focuses on the culture and improving the culture, and, in post-college application, in helping to ensure that professionals practice their profession wisely with a vision for the future and respect for the past. There is an emphasis on how to explore moral and political questions considering different viewpoints. The focus of a liberal education is not so much content mastery as it is how to recognize content mastery and make intelligent judgments.[4] Cronon describes a liberally educated person not as someone with a certain quota of content knowledge, but in terms of personal qualities and skills, including the ability to listen and hear, to read and understand, to write clearly, to solve a wide variety of problems, to act within the world in creative ways, and possessing a respect for rigor as a way of seeking truth. He states that it is not simply a group of courses but an approach.[5]

As members of the academic community, we often address broad issues with a curricular solution or approach sometimes facilitated by educational associations or societies. A 2004 report sponsored by the National Academy of Engineering suggests that the complexities faced by humanity today require a broader approach to traditional education. The high level of complexity will not abate because the pace of technological innovation will continue to be rapid and the world in which technology will be deployed will be "intensely globally interconnected". The population of users of technology will grow increasingly diverse and multidisciplinary. In such a world educators should consider as desirable attributes of technologists (in addition to their ability to understand technology) the following:

- analytical skills,
- practical ingenuity,
- communication skills,
- an understanding of business,
- high ethical standards, and
- personal character that exhibits dynamism, agility, resilience, and flexibility.[6]

In *Our Students Best Work: A Framework of Accountability Worthy of Our Mission*, the Association of American Colleges and Universities (AACU) Board reports that in our knowledge-based society, liberal education must embrace science and new technologies. They identify outcomes for liberal education that include the following:

- analytical, communication, quantitative and information skills

- understanding of and hands-on experience with the inquiry practices of disciplines that explore the natural, social and cultural realms,
- intercultural knowledge and collaborative problem solving skills,
- a proactive sense of responsibility for individual, civic and social choices, and
- habits of mind that foster integrative thinking and the ability to transfer skills and knowledge from one setting to another.[7]

So how do we as engineering and technology educators, practically provide our students with an education that includes the approach fostered by a liberal education in addition to technical content? How do we provide technical content and perspective for students pursuing a liberal education? Although there may be a myriad of approaches to the problem, an obvious tactic that would reach all students is to focus on the core curriculum (courses required of all students) and also on courses required in the technical major. By focusing on these two elements of the curriculum we have the potential to provide learning opportunities that can impact and broaden perspectives of both technical and non-technical students.

Within curricula of the College of Technology (CoT) at the University of Houston (UH), there are core courses that primarily address social and cultural impact but also have technical content, and there are technical courses that incorporate cases or simulations to engage students in thought about issues broader than just the technology. The University has encouraged courses that integrate knowledge from more than one field for many years. However, the four courses described in this paper originated from the need to provide a wider world view for technology students. The need for students to integrate technological information within the framework of society at large has been articulated by TAC/ABET (Technology Accrediting Commission of the Accrediting Board for Engineering and Technology) and the boards of industrial advisors for the programs at the College of Technology. Two courses that will be discussed are approved elements of the UH core curriculum, namely 1) The Impact of Modern Technology on Society and 2) Human Ecosystems and Technological Change. Two more courses are part of the technical curriculum, namely, 3) Enterprise Applications Development and 4) Electrical Power Systems and Industry Practices. Each course was chosen for discussion in this paper because each is either an example of providing technical content peripherally in a course with a liberal education focus or an example of providing a liberal education approach peripherally in a course with a technical focus. Courses 1) and 2) are both principally directed to students of diverse backgrounds who, through a variety of approaches, study technological and cultural issues and how they interrelate. Courses 3) and 4) are both principally directed to specific technical majors, who through cases and simulations consider issues related to societal impact of the technology they are learning. Content and activities for each course are described, and course design issues are discussed. In addition, student reactions are discussed to demonstrate the efficacy of these courses in meeting the needs of both technical and non-technical students.

Course 1: The Impact of Modern Technology on Society

This course is designed to be taken by technical and non-technical freshman students with a modest background in math. Although the course was developed and is taught by CoT technical faculty members, it is an officially designated a social and behavioral sciences core course, having been approved as such in accordance with processes and requirements set by the state.

The overarching goal of this course is to study the impact of selected modern technologies on society. To achieve this goal, students learn to use social and behavioral science research strategies as they also learn about several specific technologies.

The course content is structured around developing student understanding of three questions that must be answered.

- How is "impact on society" defined?
- What research methods employed in the social and behavioral sciences can help us analyze impact?
- How is social and behavioral science research data presented and evaluated?

The first content unit is devoted to issues that arise from all three questions. The first ideas examined relate to defining the term society and defining what constitutes impact. To prepare for class discussion, students locate and examine literature available via the Internet and in electronic journal articles available from the library. Through their research activity, issues related to the quality of information found on the Internet are discussed. What does it mean for information to be refereed? How do you know if the information you find on the Internet is founded in fact and research or bias and emotion or zeal? The remainder of the unit looks at survey and interview techniques and statistical summary techniques for data gathered in this way. Students are given examples of research hypotheses and are taught how to use summarized data to support (or not) a hypothesis. Once these fundamentals are covered in four to five weeks the remainder of the course uses these fundamentals to examine impacts of specific technologies.

The specific technologies selected for inclusion in the course vary depending on the instructor and the evolution of technologies. The course was first taught in Fall 2006 with consideration of several modern technologies grouped into three units. They were:

- MP3 players
- Internet and email
- Cell phones

In each unit, students learned the basic technological principles behind the particular technology. Thus, in the first technology unit, they learned the fundamental components of an MP3 player. Through reading assignments and class discussion, they came to a deeper understanding of technical terms and expressions used in trade journals that describe features or characteristics of MP3 players. Next in each unit, the students engaged in the construction of a hypothesis related to the technology and its impact on society. For example one such hypothesis was, "Computer games lead to violent and aggressive behavior in children." Once hypotheses were developed, each student conducted Internet and electronic library research to find literature pertinent to the hypothesis. The student deliverable for each technology centered unit was a written report summarizing and citing the resources found and a conclusion that inferred whether the hypothesis was supported or not supported. Each student also presented a brief oral report.

In addition to individual research activities, the class conducted a survey on issues associated with the impact of technology on society, using their friends and classmates as subjects. The survey instrument was constructed collaboratively during the course of the semester with students suggesting and critiquing questions. Examples of questions created include "How many computers are accessible to you in your home?" and "How many times per week do you participate in computer chat rooms?" Each student administered the survey to other students, family members, and/or friends. This anomalous administration procedure provided an opportunity to discuss issues of randomization and bias. Each student performed an analysis of the survey results using techniques presented in the class and wrote a brief report on conclusions that might be drawn.

The course was presented in a hybrid format consisting of a single lecture of 1.5 hours per week coupled with online content delivered using WebCT online course management system. In addition, some content was delivered through podcasting. Both audio-only and video podcasts were constructed and made available to students covering (mainly) the technical principles of the selected technologies. Face-to-face class time was used for class discussion and student oral reports and to keep students focused on their tasks.

Student reaction to the course was positive (anecdotally). Faculty continue to develop the course and consider other technologies. Technologies suggested for examination include radio frequency identification tags (RFID), cloning and genetic engineering, global positioning systems (GPS), nanotechnology, and anthropomorphic robots.

Course 2: Human Ecosystems and Technological Change

Human Ecosystems and Technological Change was designed to meet requirements for core courses in the social sciences. Rather than focus on a single aspect of the social sciences, faculty determined that a greater need would be filled by an interdisciplinary course which would provide students with the historical and scientific foundations of multiple social science disciplines and the opportunity to apply those concepts to consideration of the human ecological system. As an introduction to the study of human and consumer needs, values, and goals in relationship to natural, man-made, and behavioral systems, the social science orientation of the course allows students to identify, examine, and analyze current issues including those related to technology from different social science perspectives of psychology, sociology, economics, political science, and anthropology.

After being taught successfully for several semesters as a face-to-face course, the faculty decided to increase the opportunities for students to interact with technology by redesigning and offering the course online. In this way students gain experience not only with content related to society and culture but also with the Internet technology that so fully permeates today's society. Hence students are exposed to opportunities for learning on two important levels: (a) social science content and (b) computer applications.

Students in the course vary substantially in both their technical and social sciences knowledge and skill sets. Some, from technical backgrounds, are relatively comfortable with the demands of learning and using technology as a learning tool but have had little exposure to ecosystems or social science concepts. Others, familiar with the social science fields, find challenge in using and applying technology in their learning environment. Students at both ends of such a continuum have the chance to gain from the course. The marriage of technology and content in this course allows students to have positive learning experiences and extend their skills in both areas. They use the technology as a required tool to interact with and learn the content.

Beyond using traditional online course design elements such as posted content, PowerPoint presentations, chat rooms, and discussion boards. The designers of the course experimented with the addition of virtual components. Hence a pilot project was initiated to create a virtual environment within which students could access and interact with the course content. A virtual campus environment was created with buildings, trees, birds, walking paths, grass, and other campus-like attributes. Students represent themselves with an avatar and are free to enter a building related to a specific course module and select and enter doors labeled for interactive activities. Upon entering, they engage in the selected activity. At that point use of the technology has led them to an experience with the social science content. Technical fluency and a better understanding of society are outcomes that provide a foundation for the transferability of these attributes to settings beyond the classroom.

Student reactions to both the technical and social science course components are mixed. For some, because many students have made technical applications, including virtual environments such as games, part of their cultural and education environment, they enjoy the technical opportunities afforded by both the online and the virtual experiences.[8] However, for others less skilled in technology, the growth path is steeper and more frustrating yet perhaps yields greater rewards as they learn from both process (technology) and content aspects of the course. Through technology-aided interaction with the course content, they gain skills that are transferable to future situations. On the other hand, for students comfortable with a technical orientation it enables a familiar format for learning new material in the social sciences as they use that technology to broaden their perspectives as they study, contrast, and critically examine concepts and vantage points that have impacted society.

Specific course components that have had the greatest impact on students as they use and integrate both technical and social science knowledge and skills include aspects of (a) the virtual environment, (b) enhanced communication tools, and (c) formats for critical thought and discussion. Actual experience with these components facilitates not only success within the course, but also provides the scaffolding needed for the transfers of skills beyond the course. First, the virtual environment, while a hurdle for some, provides the opportunity to increase student engagement with the course and its subject matter. Second, the communication tools available via online formats allow students to communicate among themselves and with the instructor in multiple ways including chat rooms, a discussion board, and email messages. Third, the online environment affords opportunities for students to share and hear diverse viewpoints from their colleagues, which includes both technical and non-technical majors, and their instructor. This enables students to consider their own perspectives, biases, and paradigms, and then to formulate and record, for evaluation by the instructor, their own synthesis of the course content.

Course 3: Enterprise Applications Development

Baker Hughes, Halliburton, Hewlett Packard, and Exxon Mobil are global companies with a corporate presence in as many as 90 countries and customers worldwide. As multi-national corporations increase in number, effective communication across countries, cultures, and time zones is essential. Many facets of effective communication should be addressed in modern curricula such as multilingual language fluency, cultural sensitivity, and technologies that enable global communication. A team of faculty at UH is introducing technical students to an immediate, simple solution for quick, easy communication between global entities, namely audio and video presentations for asynchronous access delivered via RSS (Really Simple Syndication) technology, a.k.a. podcasting. By teaching students in three courses to use this technology through a problem based learning experience, the faculty members seek to develop both podcasting concepts and skills and cultural awareness in enrolled students. The project courses include a communication course, a leadership course, and a technical course covering internet application programming (Enterprise Applications Development). A common simulation scenario is used across the three courses in a four-phase cross-course problem based learning exercise.

The scenario presented to students in the three courses uses a fictitious global corporation named OMB that is headquartered in Blackpool, England. OMB has acquired Big!Fun amusement park in Carson City, NV. In phase I, Big!Fun is directed to prepare a complete technical description of the park's attractions together with attendance and safety data for each attraction. Students in the communication course become Big!Fun employees and work in teams to complete technical specification reports about attractions that really do exist in a virtual amusement park; this park has been built over several semesters by students previously enrolled. Together with their written specifications, the teams prepare a script stating their recommendations for what should be done to improve attractions in the park. They develop the script into a podcast that includes audio accompanied by still images. Their work has two audiences, OMB decision makers in England and OMB information services staff in Agra, India. Students discuss and consider ways to handle cultural differences that might impact the usability of their reports and podcasts.

Information Systems Technology majors in Enterprise Applications Development become OMB information services employees in Phase II. They are tasked with entering raw data taken from the Big!Fun written specification reports from Phase I into a database and then using typical information technology tools and resources to retrieve summarized data into a web-based user-friendly format for consumption by OMB decision makers in England. Their deliverables are a web application that retrieves summarized data from a database, plus a user manual for their application developed as a podcast with audio and still images.

Students in a leadership course play the role of OMB decision makers in Phase III. The teams review the data summaries delivered via the web application after viewing the user manual podcast. They also have access to the written reports and podcast recommendations provided by students in the role of Big!Fun employees. After deliberation, these student teams decide the fate of various Big!Fun attractions, preparing their decision justifications as podcast presentations with audio and images.

Phase IV of the cross-course project is a debriefing session that involves students from all the courses. Here students participate in a very open-ended discussion about difficulties they might encounter working for a global organization. Each course includes some background information on meeting the needs of the internal customer, on cultural sensitivity, and on the impact of globalization. This background information provides a common thread of information across the three courses.

The cross-course project has been implemented only once, in Fall 2006. It will again be executed in Spring 2007. In Spring 2007, faculty will attempt to have at least one student team from each course prepare their podcast deliverable in two languages to demonstrate the flexibility of the technology to accommodate different audiences. Anecdotal feedback from students to date is very positive. After the two pilot implementations are complete, all data gathered will be analyzed and the faculty team will decide whether to attempt to incorporate the project into the courses on a long-term basis. The faculty involved agree that the coordination required is prohibitive, but that student satisfaction is high.

Course 4: Electrical Power Systems and Industry Practices

Electrical Power Systems and Industry Practices is a required senior course for Electrical Power Engineering Technology students. In this course, electrical power engineering technology students learn about electrical power generating plants, the place of the electrical power industry nationwide, and thus their place, in the United States governmental, industrial, and public service universe.

The technical objective of the course is to introduce the student to basic electrical power generating plant principles. Participating students have already taken a course covering generators, so the course covers other aspects of electric generation plants. The types of generation plants covered are:

- Rankine cycle plants using steam turbines, and using coal, natural gas, or oil for fuel,
- Brayton cycle plants using gas fueled turbines, with both aero-derivative and frame turbines considered,
- Hydroelectric plants,
- Nuclear fission and fusion processes and nuclear fusion electrical generating plants.

Alternative energy sources such as wind, solar, and fuel cells are mentioned, but another class covers these topics in detail.

The electrical power industry does not exist in a vacuum. It touches every business, governmental institution, and person in the United States society. Thus, the electrical power industry is an industry operating in a glass house; that is, everyone is watching it. The relationship of the electrical power industry within this environment is of great concern to those in the industry. The relationship involves not just technical aspects of producing electrical power, but the approach and the activities of the industry that earn for it the trust and good will of the public, the regulating bodies, and the customers both large and small. Faculty believe this perspective is one of great importance to their students, and delivering it is a significant goal of the course.

To accomplish the goal of introducing the students to electrical power industry roles, functions, and relationships with the other institutions of the United States, the topics covered are:

- A brief history of the electrical power industry in the United States and the progression of the industry into investor owned, publicly regulated monopolies. This topic is included to provide the student with an understanding of the forces that formed the electrical power system as it exists in the United States. A brief mention is made of European practices.
- A study of the events and attitudes that led to the movement to deregulate the electrical power industry and the still developing outcomes of this movement. The students get a look at the reasons that deregulation of the electrical power industry began and the intended and unintended consequences, both desirable and undesirable, of the movement, which has yet to be finished. This introduction to such recent developments allows the students to analyze the process and consider various future trends.
- The history and continuing development of governmental regulation of the electrical power industry. This study is needed to help the students understand the regulatory requirements the electrical power industry must meet and why they are necessary for the reliable operation of the grid, especially in a time when deregulation of electrical power generating plants is being tried.
- The institutions that govern the electrical power industry including state regulatory bodies, the Federal Energy Regulatory Commission, the industry established North American Reliability Council and Electrical Power Research Institute are studied.

These topics are consistent with the list of attributes that technical people must possess reported in the 2004 report by the National Academy of Engineering.

One goal of the course is to provide practice for the students in calm deliberation. The discussion of nuclear power provides this practice. The students are asked to look at the processes of generating nuclear power, the perceived advantages past and present, the perceived dangers past and present, and the technological developments that impact the perceived advantages and disadvantages. The students are told that their opinion as to the desirability of nuclear power are their own, and may or may not change as a result of the material studied. The course is merely presenting the facts as they are presently understood. This section of the course is accompanied by much student questioning and discussion.

The impact of readily available electrical power on the culture of the United States is illustrated by a student exercise and in-class discussion. The electrical power industry linkages with other industries and relationships with state and local governmental bodies are illustrated by an exercise in planning the construction of an electrical power transmission line.

The course requires a term paper on some aspect of the electrical power industry and an in-class presentation on the paper. The paper topic can be some aspect of the history of electrical power, including people who contributed in a fundamental way to the industry; a technical topic, such as developments in generation, power system protection, ac or dc transmission, or distribution of substations; electrical power practices and regulation in other countries; major electrical power projects including those undertaken by governments; or a perennial favorite topic, alternate energy sources. The students regularly articulate a high level of satisfaction with the information they learn from the peer presentations.

The class discussion is normally lively but polite, and the students seem to enjoy the interaction.

A number of students who have graduated have reported back that both the technical and non technical information have been useful on their jobs. Several students have reported that the term paper gave them the confidence to prepare technical reports for industrial conferences. Others have said the term paper helped them to prepare technical reports and to feel more confident when speaking in committee meetings. The Electrical Power Engineering Technology Program Board of Industrial Advisors has commented positively about the course material, and a few employers have noted that the graduates of the Electrical Power Engineering Technology Program have a greater understanding of the industry than most beginning graduates have.

Summary

Promoting technological literacy for college-educated individuals requires attention to two aspects of technological literacy as it is currently defined. The mandate is for people to know more about the scientific underpinnings of technology and to acquire hands-on experience with technology that builds intuition about technology. The other aspect is that people in decision making positions of all types need to understand technology sufficiently in order to consider questions of impact. "If I decide to deploy a technology in a certain way, what might be the potential impact on the environment, on the culture of the people using the technology, and on the global society?" In order to produce graduates who have both characteristics, educators need to provide more courses with technical content that might be of interest to non-technical students and provide activities in technical courses that have traditionally been part of a liberal education curriculum. This paper summarizes the efforts of several faculty members in meeting the need for these two aspects of technological literacy. Of the four courses presented, two are core courses in social science with instruction in and experience with technology built in. The other two courses presented are technical courses which also present impact and context issues with respect to culture and society. The faculty involved plan to follow through with more formal study of the success of the four courses in meeting the goal of technological literacy.

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