Evaluation of a Web-based Tutorial on the History of Technology in a University Science-Technology-Society Course

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Introduction

In university settings, the field of technology has been expanded in the last ten years with courses that focus on the interactions of technology and society. These courses are presented in various ways; some focus on the ethics of technology while others take an artifact-based approach. In many cases, however, these courses expand technology to a greater student population through either General Education or as required courses in other disciplines. In broadest terms, these courses can be classified as science, technology, and society (STS) courses. The Department of Technology at San Jose State University (SJSU) has offered a STS course under the university's General Education curriculum since 1981. This course, *Technology and Civilization*, has been housed in three different General Education areas. It began as a course in the Social Sciences area and was categorized under Social Issues. In 1992, SJSU dramatically revamped their General Education (GE) program. GE was divided into lower division GE, which a student could complete a local community college or at SJSU, and upper division GE, which had to be completed at SJSU. All the classes in the upper division GE had to be interdisciplinary and include an extensive writing requirement. *Technology and Civilization* was granted advanced GE status as a course in two Areas: Earth and the Environment and Cultural Pluralism.

SJSU revised the GE program again in 1998; this revision required that the university's Board of General Studies certify all courses. The focus was put on designing the courses to ensure that the students met the student learning objectives for the GE area. The general education program at San José State University (SJSU, 1998) is different from many in the United States. Instead of specifying a specific series of courses as part of the General Education (GE) of each student, SJSU has five Core GE areas (Skills, Science, Humanities & Arts, Social Sciences, and Human Understanding and Development). In addition, every SJSU student must take Advanced GE courses in four areas: Earth & Environment; Self, Society & Equality in the U.S.; Culture, Civilization & Global Understanding; and Written Communication. Any department may propose a course for any area of GE. Beginning in Fall 2000, *Technology & Civilization* (Tech 198) was approved in the Advanced GE Area, Culture, Civilization & Global Understanding where it remains an approved course today. The department decided to move it from Earth & the Environment to Culture, Civilization & Global Understanding because the course no longer fit within the revised goals and student learning objectives of its original GE area.

Technology and Civilization is designed to introduce students to the realm of technology and to increase their awareness of both the uncertainties as well as the promises of the utilization of technology as a creative human enterprise. Tech 198 provides a comprehensive overview of the human dimension of technological change as it continually molds and shapes the nature of our social institutions and the global environment.

While science and technology are often decried as pervasive agents of social change, this course focuses on the role individuals can play in the management and control of technological forces toward human achievement. Consideration is given to the chronology of technology and its role in shaping human history. The perspective is to regard technology both as affecting and being affected by culture. Unit 1 in this course is titled "The Nature of Science and Technology." In this unit, the instructors present a historical approach to science and technology.

Technology was defined in ancient times by Homer and Hesiod as the spoken word of manual craft or cunning skill (Luna, 1994). By 330 BC, Aristotle coined the Greek term technologia and split scientific knowledge into three parts: theoretical science, practical science, and productive science (technology). From a historical perspective, philosophers of technology agree that two phases of technology can be seen: the craft phase and the modern scientized phase. According to traditional Western scientists, the roots of science and the scientific method is in Greece and Greek thought. There is a tendency among scientists to claim that not only modern science, but science in general, was characteristic of European thought. The accompanying argument in that all scientific contributions from non-European civilizations were technology-based, not science-based (Needham, 1993).

In technology development, the story is much different (see Burke (1978) for more descriptions of these innovations). There have been many Western innovations that have their basis, particularly those in printing (block printing and moveable-type printing), agricultural technology (irrigation systems), mechanical engineering (iron and lead manufacturing, efficient harnesses), and martial (gunpowder, the precursors to the barrel gun, and cannons) technology.

According to Postman (1989), the first significant shift in society's view of technology occurred at the end of the Medieval Age in Europe. He notes that until the 18th century, all cultures were tool-users. However, the main characteristic of technological development was its basis in societal need: the technologies were invented to solve specific problems in the culture. In addition, the tools were integrated into the existing cultural schema and were made to fit within the symbolic world of art, myth, ritual and religion. Technology, in these tool-using cultures, was not hostile to the belief systems of a society.

Tech 198, prior to its certification as an advanced GE course in 2000, already used a variety of multimedia to deliver the content. The approved Fall 2000 version of this course had seven units: The nature of science and technology, The History of Technology, Technology and Work, Technology and Gender Issues, Technology Transfer, Quality of Life Issues, and Ethics. Previously, Backer (1995, 1996, 2000) had developed two of these units as self-paced multimedia units that were used by all instructors in this class. In order to meet the area goals and student learning objectives of the GE area, the department decided to add a new unit on the history of technology.

This web-based unit on the history of technology was part of a reconceptualization of this course as a hybrid (self-paced multimedia/Web/in-class) delivery model. When completed, four of the units would be delivered through self-paced multimedia CDs, one would be a web-based unit, and two (Ethics and Quality of Life Issues) would be delivered in a traditional classroom mode. The department faculty had committed to retaining the two in-class units so as to provide more active learning and open-ended inquiry for the students. The key issue for all the self-paced modules was their effectiveness in promoting student achievement of the course's learning objectives.

The introduction of a new unit on the history of technology enhanced the content of this course in many ways. First, this unit addressed the contributions made by people of different cultural groups. Second, this unit, since it was positioned between the existing Unit 1 (The nature of Science and Technology) and Unit 2 (Technology and Work), provides a stronger historical context to this course and subsequent discussions of technology and society.

This paper will discuss the development of this new unit on the history of technology. Although this web-based unit was developed by the course coordinator, four other faculty regularly taught this course and all faculty used both the multimedia CDs as well as this web-based unit. It was critical to the success of this web-based unit that all faculty could feel secure in using it in their classes.

In order to retain certification as an Advanced General Education course at SJSU, all sections on this course had to meet the learning objectives for Area V. Therefore, the effectiveness of this unit in meeting the goals of GE at SJSU is critical in evaluating its content.

Design of the Web-based Module

The two previous units of this class were developed as self-paced modules on CD-ROMs that allow students to explore the topics presented in this class on their own, corresponding with other students and faculty by EMAIL (Backer, 1995, 1996, 2000). The primary instruction for these modules is by a multimedia-based document that provides an organizational structure for the course. In addition, textbooks, readings, and videotapes are required for the class.

Originally, the plan was for this new unit on the history of technology to also be developed as a multimedia CD. This plan was changed early in the development cycle. The two existing units make extensive use of video clips as an adjunct to the content in the course. However, since the history of technology module was designed to focus on the history of technology prior to the Industrial Revolution, there were fewer video clips available. Therefore, the development shifted to a web-based delivery system.

The pre-2000 version of *Technology and Civilization* began its historical view of technology and science in the Renaissance in Europe. Since technology is much older than modern science, this approach has limited the ability of students to see technology as a precursor to science. The expansion of this course to include a study of technology and culture in the Middle Ages enhanced both the students' knowledge as well as increase their understanding of the inter-relationships between technology and culture. The new unit on the history of technology also was designed to utilize the CSU image database of art and cultural images (SJSU Digital Art **WORLDART Web Database**, 2002).

As Tech 198 is approved under SJSU's Area V (Culture, Civilization & Global Understanding), this course was required to meet the Area Goals and several learning objectives (see Figure 1). This unit was designed to particularly address one of the Area Goals—"Students shall be able to identify the historic context of ideas and

cultural practices in their dynamic relations to other historical contexts." In this course, technology is the form of human expression (or ideas) studied. This new web-based unit on the History of Technology focused on how technology developed over time in three different cultures and had three distinct sections: *Technology in the Middle Ages, Islam Spain and the History of Technology* and *Chinese Contributions to Technology* (see Figure 2).

Figure 1. Area Goals and Learning Objectives for Area V of SJSU's General Education

1. Goals

Courses in Culture, Civilization, and Global Understanding should give students an appreciation for human expression in different cultures and an understanding of how that expression has developed over time in different cultures. These courses should also increase students' understanding of how other cultural traditions have influenced American culture and society, as well as how cultures in general both develop distinctive features and interact with other cultures.

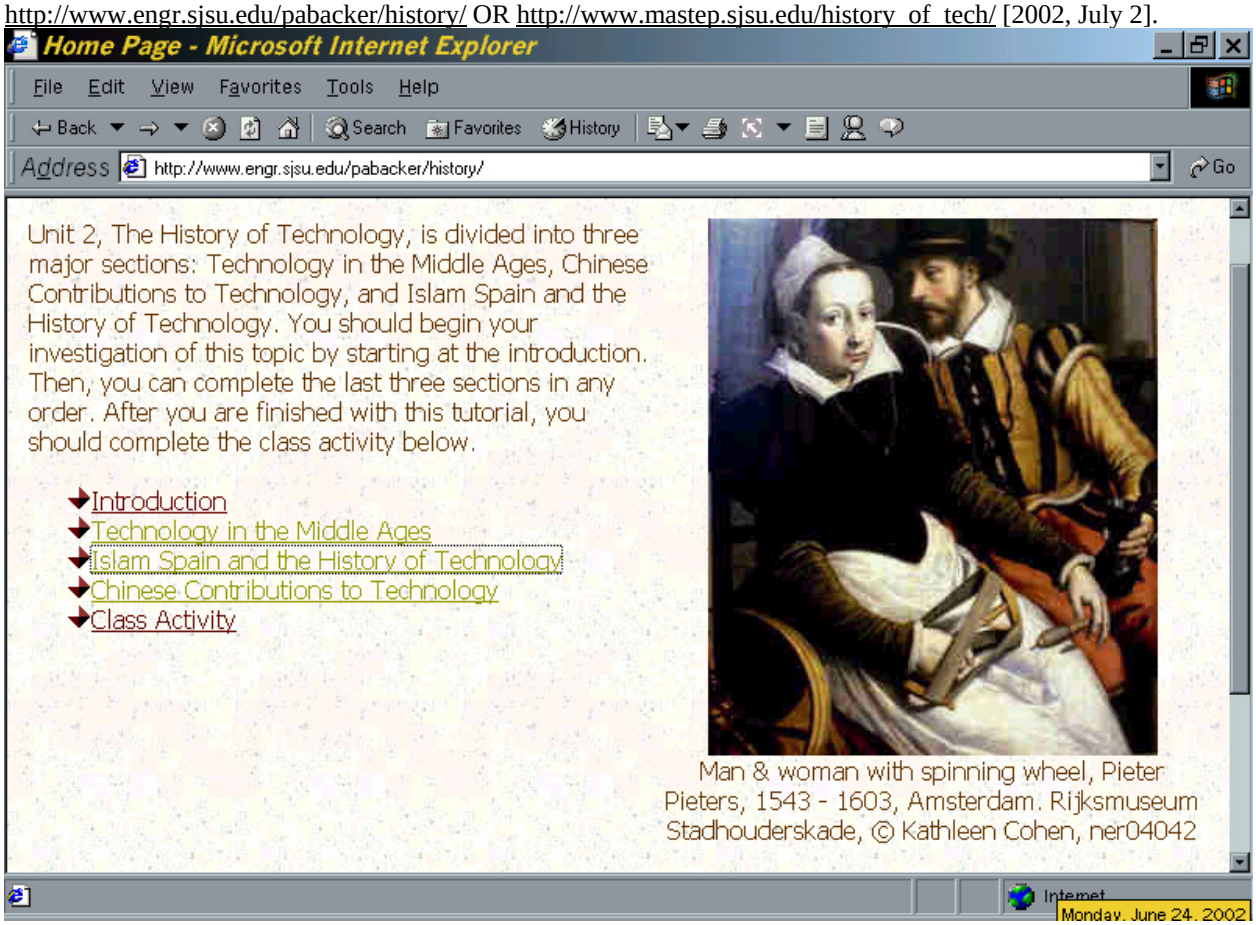
2. Student Learning

Students shall be able to:

- compare systematically the ideas, values, images, cultural artifacts, economic structures, technological developments, or attitudes of people from different societies;
- identify the historical context of ideas and cultural practices and their dynamic relations to other historical contexts; and

explain how a culture changes in response to internal and external pressures.

Figure 2. Main menu of History of Technology web-based tutorial. Available: http://www.engr.sjsu.edu/pabacker/history/ OR http://www.mastep.sjsu.edu/history_of_tech/ [2002, July 2].

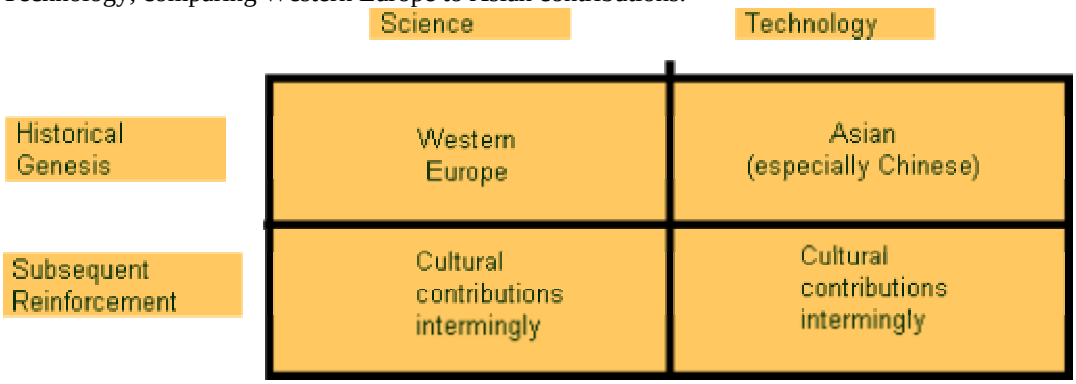


Each section of this unit was structured in the same way. The first part presented a history context for the section. This introduction, although not comprehensive, was designed to assist students without a background or appreciation of history. After reading these history sections, the student should have an understanding of the economic, political, religious and intellectual environment of China, the Islamic world, or the Middle Ages in Europe. The history section linked to existing history materials on the WWW including materials at the University of Calgary (The Applied History Research Group, 1997-2001), Western New England College (Rempel, 2000), CUNY-Brooklyn (Halsall, 1999), and the Internet History Sourcebooks Project (Halsall, 1988).

The remainder of each section focused on selected technologies and the history of their development and use. The section on Technology in the Middle Ages explored various technologies that were developed during the Middle Ages in Europe. This section focused on technologies that appear to be natively "European." The study of medieval technology was divided into six sections: Agricultural Tools, The Harnessing of Time, The Use of Iron on the Middle Ages, Weaving and the Textile Industry, and Building Construction. The content of this section was written by the author and included links to other medieval resources on the WWW including The Medieval Technology Pages (Gans, 1999), the Online Resource Book for Medieval Studies (Orb, 1999), and the Internet Medieval Sourcebook (Halsall, 1998).

The section “Chinese Contributions to Technology” focused on the many Western innovations that have their basis in China, particularly those in printing (paper, block printing, and moveable-type printing), agricultural technology (irrigation systems), mechanical engineering (clockwork, iron, and lead manufacturing, efficient harnesses), and martial (gunpowder, the precursors to the barrel gun, and cannons) technology. The web-based tutorial used Needham’s (1993) comprehensive work on China as its basis (see Figure 3). Needham sees the bottom two compartments are being able to take achievements from non-Western cultures. In the case of scientific development, Needham notes many Asian accomplishments which preceded Western developments; however, many times without directly building on them.

Figure 3. Needham’s (1993) conceptualization of the historical genesis and further developments in Science and Technology, comparing Western Europe to Asian contributions.



The last section, Islam Spain and the History of Technology, presents the contributions of the Islamic world to modern science and technology, both through the discoveries by Muslim scientists as well other knowledge that was transferred to Europe from other cultures (through Islamic Spain) including the Greeks, Persians, Indian, and Chinese. The Muslims synthesized, elaborated, and transmitted this knowledge to Spain; and eventually, to the entire Western world. In Western Europe at this time, most of the knowledge of the Greeks was lost. It was only through the transfer of Greek knowledge (including Aristotle's philosophy, Ptolemy's geography, Hippocrates' medicine) by Islam Spain that this information ever got to Western Europe.

This section was structured in a slightly different way than the other two sections. After the introductory section on the History of Islamic Spain, the author included a section that described Muslim contributions to science and technology in a historical context. This section was added after a review by focus groups concluded that there needed to be a more explicit link between the development of scientific and technological knowledge and the history of both Western Europe and Islamic Spain. Students in this course tend to think of modern science and technology beginning with the Renaissance in Western Europe—they often do not have the historical knowledge as to how most of this knowledge was transmitted to Western Europe. In the remainder of this section looked at specific scientific

innovations and technologies that were transferred to Western Europe through Islamic Spain and was divided this into three sections: mathematics, astronomy, and chemistry and medicine.

Each section of this web-based unit was designed to maximize the use of digitized primary source materials. These primary materials included art images such as Picture Arabic Book of Simple Drugs from Dioscorides' Materia Medica (Creation Date: c. 1334), a photo of the Astronomical Clock from Lyon Cathedral in France (Creation Date: 1383), and The earliest printed book found in China (Creation Date: 868). This web-based unit also contained links to text-based sources on the Web. One example, which was included in the historical introduction to the role of Islamic Spain in science and technology, had a link to three different accounts of the Battle of Tours in 732 (http://www.fordham.edu/halsall/source/732tours.html). Several text primary sources were obtained from the Medieval Sourcebook (Halsall, 1998) including a 12th century agreement on profit-sharing in a silver mine and a 13th century account of the effect of war on the woolen trade between Florentine and Flemish merchants and England. Other primary texts were obtained from the Chinese Culture web site at CUNY (Halsall, 1999); one example used in the web-based unit is The Art of Printing (late 16th Century CE) by the Western priest, Matteo Ricci, in which he describes the process of block printing in China.

At the end of the three sections, students were required to answer one of two class activities. In contrast to the class activities on the multimedia CDs for Units 1 and 3, the history of technology class activities was more complex and required that the student synthesize various sources to support their position. The students then submitted their class activities to their instructor by email or in printed form (depending on the individual instructor).

Assessment of the Web-based Unit

There are two parts of the assessment of this unit. First, there is the content assessment. The content of this unit has been evaluated by faculty from various departments at SJSU including faculty in industrial technology, history, and engineering. The second part of the assessment is centered on the efficacy of this unit as a learning modality for students.

The web-based unit on the history of technology was first used in Fall 2000 in all three sections of this course, which were taught by three different instructors. They have been used continually in all sections of the class since. This has allowed the faculty to complete a long-term assessment of the effectiveness of this module. As discussed previously, this course is structured to measure assessment by student achievement of the learning goals for Area V of SJSU's GE program. At the end of each semester, every instructor submits an assessment report to the course coordinator that describes how the student learning goals were measured and how many students met each learning goal. Each instructor may use various, and usually multiple, measures of student performance. Overall, in the thirteen sections offered between Fall 2000 and Winter 2002, eighty-four percent of the students (266 out of 316 students) demonstrated that they achieved Area V student learning objective 2. Although this web-based unit was focused on this student learning objective, the instructors of this class generally used multiple measures of student learning. Five individual sections were analyzed to determine the effectiveness of this web-based unit alone in assisting the students to meet Area V learning objective 2.

This detailed analysis of the five sections (see Table 1) showed that the history of technology web-based unit was very effective in helping student achieve the student learning goal. Most of the students in the class (71 %) demonstrated their achievement of understanding "the historical context of ideas and cultural practices and their dynamic relations to other historical contexts" by their responses to the class activities at the end of this web-based unit. Ideally, all the students should be able to demonstrate they met all the student learning goals; however, not all students are motivated to excel in all of their classes.

Table 1. A detailed analysis of the effectiveness of the web-based learning unit in assisting students to meet Area V learning objective 2, "identify the historical context of ideas and cultural practices and their dynamic relations to other historical contexts"

Semester	**Total Number of Students in Each Section**	**Students meeting learning objective 2 using all measures**	**Students meeting learning objective 2 through Unit 2 class activity**
Fall 2000	23	22	22
Winter 2001	26	23	21
Spring 2001	31	27	20
Summer 2001	24	22	12
Winter 2002	26	20	17
Total	**130**	**114 (88 %)**	**92 (71 %)**

Implications

Over the last several years, the use of the Internet has burgeoned. The World Lecture Hall (2002) at the University of Texas indexes web-based courses—it lists over 800 web-based courses that cover a wide spectrum of Internet use in the college classroom. It is common to find instructors creating a course web page that has links to their syllabus, lectures, and web links related to their course. Other courses are offered totally in an online environment and might include text, video, or audio lectures or seminar discussions through email and listservs (Bazillion & Braun, 1998). As the use of the Internet explodes, there has been little emphasis placed on the effectiveness of these web-based classes in facilitating student learning (Ehrmann, 1997). A seminal study (Russell, 1999) analyzed hundreds of articles that evaluated multimedia and web-based materials and found that overall there was little difference between technologically-enhanced courses and traditional lecture courses.

Efficiency is also a concern with web-based delivery systems. Many studies have noted the extensive time involved in developing web materials. Also, there is the issue of faculty expertise in developing web materials. Now, in addition to being a content expert, the average faculty member must become a web designer. So, the question is: Why use web-based instruction in a course?

Web-based instruction in industrial technology programs, like any other area of expertise, should only be used when they can add value to a course. The self-paced multimedia and web-based modules developed for this course fulfill this expectation. The web-based history of technology unit provides links to digitized primary sources and integrates technological development with history. More importantly, it allowed the sharing of expertise among the faculty. In essence, the faculty teaching this course will able to utilize the expertise of the course coordinator who developed this web-based unit. Since this course is taught by many different faculty, it allowed them to individually focus on selected topics in more detail after the students had completed reading the web-based material. The links to primary sources are critical to expanding the students' world views. It is extremely unlikely that, in their web surfing, they would find the text or graphical primary sources that are presented in this unit. Also, this unit requires students and instructors to expand their perceptions about technology. Including the two sections on non-Western contributions to technology have lead the students to an increased understanding of the complexities of both technological development and history itself. Each semester, several students comment as to how this unit really "opened their eyes" to either Chinese or Muslim contributions to technology.

Although some would argue that there is a lack of studies on the general effectiveness of university instruction, the existing teaching model has persevered for a long time. Now, when confronted with a new model of instruction—web-based learning—faculty need to re-evaluate the measures they use to evaluate the effectiveness of the learning experience. The student-centered model presented here focuses on student achievement rather than faculty expertise. Although used here to evaluate web-based instruction, class evaluation using student achievement of learning objectives can be applied to any teaching modality. For technology-based courses, what students learn should be more important than what instructors teach.

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This web tutorial is available at two different sites:
http://www.engr.sjsu.edu/pabacker/history/
http://www.mastep.sjsu.edu/history_of_tech/