AC 2010-1015: THE SOCIAL, ECONOMIC, AND POLITICAL IMPACT OF TECHNOLOGY: AN HISTORICAL PERSPECTIVE

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The Social, Economic, and Political Impact of Technology:
An Historical Perspective

Abstract

Our modern lives are filled with technologies. In fact, they have become so integrated into our lives that many of them are frequently used but never really thought about. Few people stop to consider that civilization once lived on without them. Many of these technologies are so common today that they have become almost invisible. The impact of technology on our lives is substantial, even though it may not be obvious, understood, or even considered. For many, it is simply accepted. Technologies have changed the way people live, work, and play. However, this is not a new phenomenon. Technology has changed civilization in many ways throughout all of history. Today, few people stop to consider the social, economic, and political impact technology has had on our lives. To address this issue, an interdisciplinary junior level course has been created that explores a historical perspective of the development of technology in a global context. The social, political, economic and cultural impacts of technologies are explored to determine their positive and negative effects. In this context the two biggest technology drivers of agriculture and war are studied in detail. Through innovations agriculture was able to produce more food allowing populations to grow. While new inventions created more effective and devastating weapons of war used to kill and destroy. Throughout the course, numerous technologies are scrutinized and examined in terms of their cost versus benefit to society. It also investigates how technologies are inter-related and how cultural factors affect the acceptance or rejection of technology. The intent of the course was to enhance the student's understanding of how technologies developed and why. The material covered helps the student to understand and recognize our dependence on technology and its impact on our lives. In this course the students study the past development, use and effects of technology in order to be better prepared for the new technologies of the future.

Introduction

Throughout history, new inventions and innovations have produced more food, created new tools, made life easier, and war more devastating. Today technology influences and affects every aspect of our life. However, we often forget that it profoundly affected the lives of past generations dating back to the beginning of civilization. Perhaps not to today's extent, but the impact was still dramatic.

An interdisciplinary course was created a number of years ago (Loendorf[5]) that explores a historical perspective of the development of technology in a global context. This junior level course (TECH 393), titled Technology in World Civilization, traces the interconnected events and cultures in which technology developed. It investigates how technologies are inter-related and how cultural factors affect the acceptance or rejection of technology. The intent of the course was to enhance the student's understanding of how technologies developed, why they were used, and their impact on society. This course traces the evolution of technology and its impact on

civilization from the creation of elementary tools up to today's latest devices and even looks into future technologies.

Numerous questions or mysteries of the past are addressed. For example, why did similar inventions appear in different parts of the world almost simultaneously? How did information and technology spread from one place to another and why did they fade away in one place only to resurface later in a different place? How and why were inventions or innovations diffused or borrowed from one culture adapted to suit the needs of another?

Teaching methods include lectures, discussions, videos, and written essay projects. The lectures and discussions are designed and intended to be very interactive and engaging for the students. The selected videos show how past technologies were developed and used. The essays require students to identify and apply the knowledge obtained from the course to both historical and today's technologies. The students are challenged to be creative and innovative in their solutions to the problems presented to them.

This interdisciplinary course satisfies the University's International Studies graduation requirement. As a result, students from all disciplines across campus regularly take the course leading to a great diversity of backgrounds and specialties. Perhaps this explains the wide spectrum of opinions, comments and ideas expressed both in the class discussions and in the written essays.

Objectives

The course has two main objectives: (1) promote awareness of technological development, and (2) provide a rudimentary understanding of the social, political, economic and cultural impact of technology. These two main objectives were then expanded to create a more comprehensive list of objectives for the student. Upon completion of the course, a student can:

1. Recount the interconnected events and cultures in which a technology developed.
2. Describe how technologies are inter-related.
3. Critique technologies based on: system aspects, applied knowledge, specific goals, organizational forms, winners/losers, etc.
4. Describe a world technological problem (weapons, fuel usage, public health, etc.) from both a developing nations and technologically advanced nations viewpoint.
5. Recount the development of major technologies historically.
6. Understand and can cite examples of technological dialog and diffusion.
7. Recognize occurrences of "technological determinism" and "social constructivism."
8. Cite examples of cultural factors affecting the acceptance or rejection of a technology.
9. Discuss issues relating to technological advance and cultural lag.
10. Describe how the "convergence theory" has affected the world's nations and brought them closer together.
11. Understand the dilemmas relating to halfway technologies.
12. Recognize our dependence on technology and understand its invasive nature.
13. Understand the use of appropriate (Western) technology in developing world cultures.
14. Recognize that engineers of previous millenniums were very smart!

In addition, these objectives were designed to respond to the Accreditation Board for Engineering and Technology[1] (ABET) requirements listed in its Engineering Criteria 2000.

Structure

The four credit (quarter system) course meets for an hour four days a week. The majority of the class sessions are lecture and discussion based. For variety, demonstrations of collected or recreated artifacts occur frequently. Videos varying length from five to 50 minutes are also utilized to augment the lectures and written material from the textbooks.

Numerous historical videos are available from sources like The History Channel, The Discovery Channel, PBS, BBC and other sources. The selected videos show the students detailed information on: the Great Wall of China, early machines, ancient weapons, the industrial revolution, railroads, the environment, and other topics. Through these videos, the process of independent innovation is explored along with the possibility that many inventions were related or somehow connected.

Two or three books are used for reading assignments and discussion purposes. They are reviewed periodically as new or updated texts become available. Excellent example books are available from Alcom[2]; Hjorth, Eichler, Khan, and Morello[3]; Johnson, Gostelow, and King[4]; Pacey[6]; Stross[7]; Teich[8]; Voland[9]; and Volti[10].

A series of four written essays based on the readings, lectures and discussions are assigned. Representative topics have included history's most important innovation or invention, the historical development of a technology, a technology's most beneficial and harmful effects, and society's choices about what technologies to accept or reject. The projects challenge the students to identify and apply the knowledge obtained from the course to both historical and today's technologies. The students are expected to be creative and innovative in their solutions to the problems and scenarios presented to them.

Over the years, multiple formats for the exams were used ranging from essay, short answer, true or false, fill in the blank, matching, and multiple choice. Various combinations of these methods were also tried with varying degrees of success. However, the large amount of material covered in the course caused a problem for many students. Each of the four exams covers between six to eight chapters from the textbooks along with all of the material discussed in class. In order to overcome this issue, a combination of short answer and multiple-choice questions were used. The average exam scores using this assessment method improved from the low 60s to the mid 70s.

The student's final grade is derived from their scores on the four exams and four essays. The exams and essays each determine half of the student's final grade. That is, each exam or essay represents one-eighth (12.5%) of their course grade. Overall, eight graded assignments are utilized to calculate the final grade. As a result, a single poor grade on an exam or essay does not significantly detract from an otherwise good performance.

Class participation is encouraged and considered in the final grade where close decisions are required. Attendance is taken daily by using a sign in sheet with penalties imposed to discourage absences. Anything discussed in class (including the content of videos) is fair game to be included on the exams.

Content

It would be impossible to cover in a ten-week quarter all of the social, political, economic and cultural affects of technology on civilization. Instead, the focus is on a few major categories that encompass a wide variety of subjects. The course content is continually being revised and updated, however the typical topics covered include:

Agricultural Development. How did civilization progress from hunting-and-gathering societies to slash-and-burn cultivation and then to settled agriculture? What crops were planted and where did they originate? Why did they make a difference? What tools were used and when did animals and machines begin to help with the work? How was the number of acres used for food production increased? What methods improved the crop yield per acre? What led to irrigated fields and how was the water moved from one place or level to another?

Weapons Development. How did the action-reaction escalation of weapons development begin and why does it continue to this day. Civilization progressed from the axe, to the spear, and then to the bow and arrow. Fortifications and body armor surfaced. Catapults and trebuchets were invented as siege weapons. What was 'Greek fire' and what part did it play? Then the discovery of gunpowder changed everything. Now cannons, crude guns and rockets appeared. Traditional military tactics and procedures were altered as one devastating weapon followed another.

Industrial Revolution. Civilization moved from human power to animal power and then to water and wind power. Windmills and waterwheels supplied the energy to grind grain, spin textiles and run other machines. The craft industry utilizing self-employed workers was transformed into an army of employees working in factories. Machine-paced labor led to a form of wage slavery. Guilds and unions were formed. Coal emerged as the main source of energy only to be replaced by oil. The steam engine powered industry and transportation until it was superseded by the internal combustion engine. Then electricity and all of the devices powered by it changed how and when we worked.

The Environment. What affect did early humans have on the world around them? What happened as the number of humans increased? As new technologies developed what affect did they have on the earth's natural resources? What type of shortages developed and where? How was the depletion of resources handled? Substitutions were made, but what new problems did they create? When and where did pollution begin to be a problem? What was done about it?

Communication. It all began with the spoken word and progressed to the written word. Surprisingly, not all languages had a written counterpart. What happened to those without a written form? Stone tablets were the first form of permanent records. Manuscripts were copied by hand before the printing press was invented. Wooden blocks and copper plates were used before moveable type. Then the telegraph revolutionized communication only to be over

shadowed by the telephone. The quest for instant communication continued with the invention of radio, television, and the Internet.

Transportation. Initially humans walked and carried what they needed. A huge step forward occurred when animals and crude carts were used. Waterways became the prime mode for transportation and trade. Great vessels traveled the world's oceans, rivers, and canals. Only to be supplemented by the steam engine powered locomotive and the age of railroad empires began. Then the automobile, mass produced on assembly lines, became the prime mode of transportation. Airplanes then emerged in the further quest for speed to get from place to place.

Numerous other topics are routinely investigated and discussed. The course was designed in order to allow for a great deal of flexibility. The material covered, in many cases, can even be tailored to the particular class's interests. In reality, no two classes are ever quite the same.

Essay Topics

Essay topics are modified, updated, or replaced almost every quarter. This is due in part to the direction the class takes during the discussion of the material. It also reflects the dynamic selection of the material covered in the course. The students respond to technical and historical scenarios by writing a sequence of five page essays supporting their conclusions. They must build a case that strongly supports and backs their decisions by finding, evaluating, incorporating and stating facts by citing resources using APA Formatting. The students are given two weeks to complete each essay. A typical four-project sequence is presented below.

The first project requires the determination of the most important technology, innovation, or invention for civilization as a whole and then for society today. They are asked to carefully consider all of the alternatives and respond to the following two questions. (1) What innovation or invention (technology) had the biggest impact on civilization throughout history? (2) What innovation or invention (technology) has or had the biggest impact on your life? Think broadly and reflect on technologies that we cannot live without. For the first question, the technology must be at least 50 years old. That is, it was first widely utilized either before or during the 1950s. Consider how civilization was affected by this technology over time. For the second question, exclude the obvious ones: birth control, television, computers, the Internet, cell phones, automobiles, airplanes, IPODs, electronic games, etc. and concentrate on the big picture. Do not overlook some of the most common things that we often take for granted. Consider how you personally and society overall have been affected by this technology.

The goal of the second project is to trace the development of a technology historically. The students are asked to pick a technology that is part of everyday American life (for example: automobile, clean water supply system, electrical utility system, telephone system, etc.). Then trace the development of the technology for at least the past 100 years. Collect information about key events during the development of the technology. Find at least 25 events with at least five of them not being scientific or technical in nature (for example, government regulations). Describe the events in chronological order including: the date - when did the development happen (or what time period); the event - what development happened (this may include scientific,

technological, governmental, cultural or other events); and the significance - why the development was noteworthy.

The third project requires an investigation into the most beneficial and harmful effects of technological innovations or inventions. As we have seen numerous times, a good technology has often unknown (at first) adverse affects while a bad technology has been utilized in some way to improve civilization. Often times they occur together. The students are asked to respond to the following two questions. (1) Which technology has produced the greatest benefit to civilization? Were there any harmful affects? What are they? (2) Which technology has produced the most harm? Were there any beneficial affects? What are they? Once again, the student's are encouraged to think broadly and consider all types of technology. There are some obvious choices for both of these questions and many selections that upon thoughtful consideration might be actually more significant.

Society makes choices about what technologies to adopt or reject. Some of the consequences are good, and some are bad. The fourth assignment is to compare the results of the choices once made. Students must select one of the following three topics for discussion. Topic 1 - Alternative energy source to replace US dependence on foreign oil. Investigate one modern alternative energy technology and discuss its pros and cons. Topic 2 - Controlling Weapons of Mass Destruction. Investigate a weapon of mass destruction, the political environment, the control of the use of the weapon historically, and how use of the weapon could be controlled in the future. Topic 3 - Environmental Threats. Investigate and determine the greatest environmental threat facing the world today, what countermeasures need to be implemented, where will the resistance come from, and what will the solution cost. Then describe how the technology works by de-mystifying the technology. Compare and contrast the potential gains to the potential risks. What are the problems associated with the technology and how to deal with them. Are there any laws that could be put in place (or are already in place) to limit the risks or moral problems. How would various cultures around the world view the use of the technology?

New Technologies

The course also examines the affect of technology on our lives today as well as looking into the future. The dilemmas of new and emerging technologies influence our lives in many ways. Everything from our life at home to our life on the job has changed.

The threat of technology driven unemployment is real. It has happened in the past and will happen again in the future (Johnson, Gostelow, & King[4]). However, there is a case for optimism because new technologies create new jobs and opportunities. The vast majority of jobs today did not exist twenty years ago and this trend will continue (Volti[10]). Lifelong learning and continual retraining are necessary to insure that workers skills are up to date and relevant for the new jobs being created(Voland[9]).

The change in the U.S. economy from manufacturing based to service oriented has profoundly changed the jobs of the future. In the 20th century, a revolution in how work was organized and the diffusion of information technology have altered what workers produce and how they produce it (Volti[10]). Few jobs in the future will be directly related to the production of objects

while the majority of jobs will provide services or manipulate data to create information (Teich[8]).

It is therefore important to understand that change occurs and that things will be different in the future. The goal and objectives of this course are to make the students aware of this process and prepare them for change. By learning and gaining an understanding from the past development and use of technologies they will be better equipped for the future regardless of the social, political, economic and cultural changes that result from these new technologies.

Conclusions, Reflections and the Future

This course exploring a historical perspective of the development of technology in a global context has achieved its objectives of increasing the awareness and understanding of the social, political, economic and cultural impact of technologies on society. Through innovations, agriculture was able to produce more food allowing populations to grow. Meanwhile, other new inventions created more effective and devastating weapons of war used to kill and destroy. Throughout the course, numerous technologies are scrutinized and examined in terms of their cost versus benefit to society. It also investigates how technologies are inter-related and how cultural factors affect the acceptance or rejection of technology.

Reflecting back on the course itself, it is intended to be fluid, dynamic, and current implying that it is rarely ever the same. The content is constantly updated and the essay topics frequently revised. The course must keep pace with the changing times and technologies. This is as it should be because technology continues to impact and influence society.

The intent of the course was to enhance the student's understanding of how technologies developed and why. The material covered helps the student to understand and recognize our dependence on technology and its invasive nature into our lives. In this course the students study the past development, use and affects of technology in order to be better prepared for the new technologies of the future.

Bibliography

1. Accreditation Board for Engineering and Technology, at http://www.abet.org
2. Alcorn, Paul. *Social Issues in Technology:, A Format for Investigation*, 4th ed. Upper Saddle River, NJ: Prentice Hall. 2003.
3. Hjorth, L., Eichler, B., Khan, A. and Morello, J. *Technology and Society: A Bridge to the 21st Century*, 2nd ed. Upper Saddle River, NJ: Prentice Hall. 2003.
4. Johnson, S., Gostelow, J. P., and King, W.J. *Engineering and Society*, Upper Saddle River, NJ: Prentice Hall. 2000.
5. Loendorf, W. R. (2004). A Course Investigating Technology in World Civilization. *Proceedings of the American Society for Engineering Education (ASEE) Conference*, Salt Lake City, Utah, June 20-23, 2004.
6. Pacey, Arnold. *Technology in World Civilization*, 4th ed. Cambridge, MA: MIT Press, 2001.
7. Stross, Randall. *Technology and Society in Twentieth Century America*, Belmont, CA: Wadsworth Publishing Company, 1989.

8. Teich, Albert. *Technology and the Future*, 11th ed. Toronto, Ontario, Canada: Thomson Wadsworth Publishing, 2008.
9. Voland, Gerand. *Engineering by Design*, 2nd ed. Menlo Park, CA: Addison Wesley Longman, Inc., 2003.
10. Volti, Rudi, *Society and Technological Change*, 6th ed. New York: Worth Publishers, 2009.