Abundance, Order, and Meaning:
Reconceptualizing the Role of Technology in Global Cultures

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One of the key outcomes of ABET 2000 is to provide engineering students with "the broad education necessary to understand the impact of engineering solutions in a global and societal context." In my view, the intellectual challenge in fulfilling this outcome is to provide our students with a framework that moves beyond modern, Western assumptions about technology and allows our students to understand that non-Western cultures may view technology in very different ways. It is all too easy for our students to presume that technology is simply the means for pursuing several material and economic goals: creating wealth, maintaining military power, improving health, and providing entertainment. While all of these goals are necessary and valuable, it is often hard for our students--and the public in general--to understand that people may also use technology in pursuit of noneconomic goals such as social order and cultural meaning.

Drawing on the research I did in writing and editing *Technology in World History* (6 volumes, Oxford University Press, forthcoming), I will outline in this paper a framework for thinking about how people use technology to create and sustain their cultures. This framework--that people use technology to create abundance, order, and meaning--has proven useful in teaching about technology in ways that don't privilege Western developments and conceptions of technology. This framework also permits us to treat Western and non-Western cultures in a balanced or symmetrical fashion and thus help students understand the impact that engineering can and will have in diverse cultures around the world.

An Overview of the Project

It has been over thirty years since the last general history of technology has been published by American scholars, namely Kranzberg and Pursell's *Technology in Western Civilization* (1967). At the same time, no one other than Arnold Pacey (1990) has attempted to prepare an accessible, general history of technology that includes the development of technology in non-Western cultures. In response to this gap, I approached a book-development company in

England, Andromeda Oxford, to develop a six-volume project titled *Technology in World History* (TWH). Andromeda specialized in the production of high-quality illustrated scientific reference books and provided extensive editorial and design support.

In terms of audience, Andromeda and I decided that we should develop TWH for general readers and that it would be marketed to US public and high school libraries. Hence, TWH is more of a reference work than a textbook. For publication in North America, Andromeda sold the project to Oxford University Press. Andromeda will subsequently market the foreign rights to this project, and it could very well wind up appearing in French, German, Russian, and Japanese.

At the outset, Andromeda and I decided that we should not attempt an exhaustive survey of all technologies in all societies. Instead, our goal was to examine the role of technology in selected societies and time periods. And rather than have the technology drive the narrative, we decided that culture should be the dominant element in the project. The mission of TWH was to locate technology in human history and to examine the numerous ways in which people have used technology to form and sustain their culture. Along with language, religion, and social structure, technology is part of the culture of a given people, and perhaps more than any other element, people use technology as the means to shape and manifest their values and beliefs. Hence, the guiding thesis for TWH has been that, while all cultures have technology, every culture uses technology differently. Ideally, the project should provide a panoramic view and invite readers to compare the technological choices made by people around the world and across the centuries.

As Table 1 shows, TWH has eighteen chapters. It begins and ends with two broad chapters covering the Stone Age and Globalization. Along with 9 chapters covering technology in Europe and America, there are 7 chapters, which investigate the role of technology in non-Western cultures. The non-Western chapters cover India, China, the Islamic world, Africa, the Pacific, as well as the Maya and the Aztecs. In selecting these chapters, Andromeda and I had to take into account what civilizations are currently covered in standard social studies curricula in primary and secondary schools in the US; Oxford University Press was quite keen on this in order that they can market the project to a very wide audience.

Table 1

TECHNOLOGY IN WORLD HISTORY

VOLUME 1: PREHISTORIC AND ANCIENT WORLD
1. The Stone Age, Michael Geselowitz (IEEE and Rutgers University)
2. Ancient Egypt, W. Bernard Carlson (University of Virginia)

3. Ancient and Classical India, Bryan Pfaffenberger (University of Virginia)
VOLUME 2: EARLY EMPIRES
1. Early China, Francesca Bray (University of California, Santa Barbara)
2. The Ancient Mediterranean, Geselowitz
3. The Romans, Carlson
VOLUME 3: THE MEDIEVAL WORLD
1. Medieval Europe, Pamela Long (Washington, DC)
2. The Islamic Empire, Thomas Glick (Boston University)
3. Late Imperial China, Bray
VOLUME 4: TRADITIONAL CULTURES
1. Africa, David Killick (University of Arizona)
2. Pacific Peoples, Fred Damon (University of Virginia) and Geselowitz
3. Mayas and Aztecs, Jeremy A. Sabloff (University of Pennsylvania)
VOLUME 5: THE INDUSTRIAL AGE
1. Early Modern Europe, Carlson
2. The Industrial Revolution in Europe, Carlson and Kristine Bruland (University of Oslo)
3. Early Industrial America, Carlson
VOLUME 6: THE TWENTIETH CENTURY AND BEYOND
1. The United States, 1870-1970, Carlson
2. The Soviet Union and Nazi Germany, Jonathan Coopersmith (Texas A&M)
3. The World since 1970, Carlson

Since a central goal of the project was to bring the latest scholarship to a broad audience, I sought experts for as many of these chapters as possible. In the course of commissioning authors, I quickly discovered that there are very few historians of technology who study anything other than the US or Europe. Equally, the pickings are mighty thin once you need people who are knowledgeable about events prior to 1700. Fortunately, I was able to find a number of outstanding anthropologists who prepared the non-Western chapters. In several cases where an expert was not available, I took on those chapters (for example, Egypt, Rome, and early modern Europe). I also wrote an overall introduction to the project as well as introductions to each of the six volumes.

Abundance, Order, and Meaning

Once the authors had been selected, the next challenge was to create a framework to guide the development of the individual chapters. In particular, it was crucial to provide the authors with a framework that covered the basic topics but at the same time didn't put them in a straitjacket. I was especially concerned that the non-Western chapters be able to tell the story of how those cultures pursued their own distinctive technological trajectories. Toward this end, I suggested to the contributors that they think about how different cultures

use technology to address three general areas: material abundance, social order, and cultural meaning.

I assumed that most readers will come to TWH with practical questions about how people have used technology across the span of history. Readers will want to know how each civilization produced the material abundance necessary to sustain the population and permit the development of distinctive culture. Hence, each contributor was asked to try and answer the following questions in his or her chapter:

- How did the group produce food?
- Where did they live (houses, settlements, and cities)?
- What did they wear (clothing and jewelry)?
- What materials (ceramics, wood, metal) did they use to fashion objects?
- What sources of power (human muscle, animals, wind, water, steam, electricity, nuclear) did they utilize ?
- How did they move themselves and goods (transport)?
- How did they defend themselves or attack other groups (weapons)?

This first set of questions constitutes what might be called the instrumental or economic functions of technology.

However, the real opportunity for TWH was in combining a discussion of the instrumental functions of technology with an exploration of its social and ideological functions--how humans use technology to structure their communities and give life meaning. (Schiffer, 1992)

I assumed that TWH's readers are probably vaguely aware that technology is more than just the tools humans use to provide food, shelter, and clothing. Whether one considers grand monuments such as the Pyramids and the space program or personal objects such as jewelry or Palm Pilots, one quickly realizes that humans possess technological artifacts for non-economic reasons. Technological artifacts can confer social status, provide aesthetic pleasure, structure social interactions, and provide meaning to human existence. Yet while people have an inkling that technology has more than just instrumental uses, they lack the concepts or examples to think about the social and ideological functions of technology. Consequently, one of the major goals for TWH is to

introduce readers to the powerful idea that technology is used by humans not only to provide material abundance but also social order and cultural meaning.

Toward this end, I suggested that each chapter look at several questions related to the ways that human groups employ technology to create social and political order:

- How do people use technological artifacts to distinguish between groups (by gender and class) and confer social status?

- What artifacts are used to guide or control the behavior of individuals or groups?

- How does society use artifacts to deploy political power, to designate leaders and followers?

- How do leaders collect information and communicate in order to coordinate the activities of their societies?

- How is technological knowledge distributed in society? Is it broadly distributed in terms of skill or is it concentrated in the hands of a few experts?

Across the chapters of TWH, the authors offered myriad examples of how people have used culture for social and political order. In the Aztec civilization, only the ruling and warrior classes were permitted to where elaborate outfits fashioned out of feathers. In ancient China, the emperor displayed his power by standardizing all aspects of language, law, and religion. He went so far as to place tracks in the Imperial roads so as to force the peasants to use carts with a standard wheelbase. And I suggested in my chapters on the 20th century that information technology has been driven as much by a desire for social control (by collecting information about citizens) as it has been to improve economic productivity.

Along with social and political order, each chapter was to examine the ideological functions of technology. Here I am not talking about ideology in the Marxist sense--that is, simply the explanations put forward by the ruling class to justify the status quo; rather I thought we should explore ideology in the sense of the multiple ways that humans attempt to explain their existence and to give it meaning. We considered how technology interacts with the myths, religion, art, and philosophy of a culture. The questions thus included:

•How do groups use technological artifacts to illustrate and reify their worldview?

•How do artifacts reflect a group's views about the place of humans in the universe? How do artifacts reflect notions of time and space?

•What do artifacts reveal about how a group addressed and tried to resolve central puzzles or traumas?

Let me offer two brief examples of the relationship between technology and cultural meaning. First, in writing about the Egyptians, I made the point that the pyramids served no economic purpose--in fact, their construction took significant numbers of workers away from agriculture. Instead, the pharaohs and people of Egypt undertook the construction of the pyramids in order to make manifest their beliefs about the afterlife--if the pharaoh was willing to devote substantial resources to his palace for the afterlife, then there must be some basis to these beliefs.

Second, in his chapter about Pacific peoples, Fred Damon revealed that boats are much more than a form of transportation. Pacific islanders use boats as a metaphor for talking about their community and for organizing gardens on land. They also use the process of sailing and navigating for thinking about their role in the universe; in fact, their ability to think in the same terms about the practical task of navigating and their place in the universe probably goes a long way to explaining why Pacific Islanders are able to sail across thousands of miles of open sea relying only on memory and star sightings..

You would be right to think that it was a tall order to address these three functions of technology--abundance, order, and meaning--with detailed examples in a 10,000 word chapter. Yet, I think my co-authors often succeeded in doing so. But of course, we will have to see what readers and reviewers think.

New Insights

As the chapters came in for editing, I was fascinated by what you learn when you compare cultures side-by-side. For example, having taught the history of American technology, I was familiar with how technology moved from England to America by way of workers, spies, and scientific delegations, but I was surprised to learn that similar means were used by the French, Germans, and Scandinavians to secure British technology in the mid-19th century.

Even more surprising was to have the opportunity to compare the river-based civilizations in the Fertile Crescent, Egypt, India, and China and realize that these "hydraulic" civilizations developed very differently. These differences arise, in

part, because the rivers and climates in each region vary dramatically. In Egypt the challenge is to take advantage of the silt carried by river during the spring flood while in the Fertile Crescent, the goal was to capture water to be used for irrigation during the dry season. Even more remarkable, as Bryan Pfaffenberger pointed out, the early Indus civilizations appear to have been far more egalitarian than either Egypt or Babylon. All of this suggests that there is no simple link between irrigation technology and political structure. Contrary to Lewis Mumford's (1967) notion of the megamachine, irrigation technology did not set humans on the course of creating the oppressive state. Different ancient civilizations developed different irrigation technologies and established political order in response to various ideas. These are only two examples of the sort of comparisons that I think need to be made to enrich the history of technology.

In comparing civilizations, another issue that jumps out is the role of large-scale environmental change. For some time, historians have argued that climatic change has created key turning points in human history: people moved into the Nile valley 10,000 years ago as North Africa turned into a desert and the Roman Empire collapsed in part because of a mini-Ice Age in the third century AD. However, I was amazed to learn that the civilization that grew up around the Indus River disappeared between 2000 and 1700 BC. Some scholars believe that the Indus civilization was destroyed by a climate change that turned the once-fertile landscape into a dry, dusty desert; others attribute the downfall to flooding. Equally, the Mayan civilization went suddenly into decline after 700 AD, and some suspect that climatic change played a part. What these examples suggest to me is that we need to think about the role of environmental change; clearly, civilizations shape technology to suit the prevailing climate and geography, and they are hard-pressed to adjust to large-scale change. In our analysis of technological change, we need to take environmental change into account.

A third issue concerns notions of change. In the course of writing the chapter on Roman technology, I read Peter Green's (1990) essay on Hellenistic technology and I was curious to learn that the Greeks were deeply suspicious of change. For the Greeks, the ideal state of a body was at rest, and Green argues that this suspicion of motion and change effectively limited the development of mechanical technology (such as Heron's famous steam engine) in the ancient world. This suggests to me that we might visualize the Greek perspective on change as a straight horizontal line.

At the same time, in his chapter on Islamic technology, Tom Glick describes the writings of the 14th century Arab historian Ibn Khaldun (1332-1382). Khaldun viewed history as a cyclical and progressive process in which nomadic peoples adopt urban life and become civilized, attain a peak of cultural development, only to be corrupted by their success and destroyed by another, more vigorous group. To

me, Khaldun's view should be visualized as a train of waves following a rising line. Khaldun explicitly discussed the role of technology in shaping a culture, arguing that technology gives a civilization its distinctive character.

Taken together, these two perspectives got me to thinking about how notions of change might influence the trajectory of technology in different civilizations. If a culture (such as the Greeks) takes a static view, then certain technologies are developed and others not pursued. While Heron wrote about his steam engine and other inventions, his writings were ignored by other Hellenistic scholars since they didn't fit into the general worldview (and of course Heron's books were not read by skilled craftsmen).

Equally, if a culture anticipates change, then that attitude can facilitate the development of particular technologies. One of my favorite examples of this is Prince Henry the Navigator. In the chapter on early modern Europe, I argued that Henry was perhaps the first "modern" in that he believed that his kingdom should change (i.e., become richer), and he deliberately turned to technological innovation--improving ships and navigation--to achieve that end.

I should hasten to point out that this line of thinking doesn't privilege the Western notion of progress--that it is the only one that facilitates the rapid development of technology. For instance, during the Tang dynasty, the Chinese state promoted a variety of technological improvements in order to raise agricultural productivity and to establish new industries such as porcelain and silk. For the Chinese, the goal was not to alter the status quo but to reinforce it. Hence, what I think is important here is that we see progress as one of only several perspectives that can influence the course of technological change. To borrow from John Staudenmaier (1985), not only does "progress talk" generate technology but so does "stasis talk" or "cyclical talk."

New Challenges

These are only a few of the new things that I have learned in putting TWH together. In addition, the project changed the way I think about--and teach--the history of technology to engineering students.

The first challenge concerns description versus explanation. As I worked on my chapters, I became increasingly aware of the difference between these two things. In writing about Roman technology, for example, I found it relatively easy to describe their major accomplishments--the roads, aqueducts, even their remarkable pipe organs (*hydraulis*). Yet to shape these descriptions into a narrative, I had to come up with an explanation of why the Romans produced these artifacts and systems. To my consternation, I discovered that most historians have not really

worried about why the Romans produced these technologies--it's just assumed that the Romans had these technologies. In the end, after consulting with a colleague at UVA who specializes in Roman history, I came to argue that technological change in Roman times was driven by the patronage of aristocratic landowners. This powerful group (of whom the emperor was the exemplar) supported technology that allowed them to (a) generate an agricultural surplus, (b) demonstrate their power through spectacle and public works, and (c) gain power through military prowess.

In a larger sense, my experience in writing about Roman technology served to remind me about what we should be trying to do when we teach the history of technology to our students. While we are able to do a great job describing the technologies used by particular groups or individuals, we are not as strong in terms of explaining why a society as a whole makes the technological choices that it does--and explanation is what our engineering students need if they are going to be effective designers and leaders. Perhaps it may seem obvious, but we need to remember that the first step in the design process is problem specification, and problem specification turns on knowing what needs to be "done" on a variety of levels--individually, company-wise, and culturally. To frame problems effectively, engineers need to think about why and how a given culture views technology. And in the global economy, students need to be able to differentiate between how their culture views technology and how it might be viewed differently in a culture this is the recipient of their designs.

I am especially concerned with how effective we are at narrating the links between abundance, order, and meaning. Karl Marx was clearly on to something when he argued that the economic structure of a society (the means of production) could influence the shape of the superstructure (the art, religion, and culture). Yet, if the history of technology has accomplished anything it has been to show that the relationship between structure and superstructure is not deterministic--the steam engine does not automatically give you industrial capitalism. Indeed, what we have been discussing for years in the history of technology and engineering humanities circles is that the superstructure--in the form of values, ideas, dreams, and wishes--influences the structure--at least in terms of the technological choices that are made. (Smith and Marx, 1994)

Nevertheless, we do need to come to terms with the fact that technology helps generate the material abundance that is essential for the development of any civilization. If a civilization can't produce enough food to feed its people (or wealth or weapons to secure food from others), then it won't survive. To be sure, ideas and mindsets--the very stuff of culture--certainly do guide the leaders and technologists in a particular civilization in the course of figuring out how to go about creating a material abundance. But the fact still remains that we need to come up with an

interpretive framework that creates a balance between the economic/materialist functions of technology and its social and cultural functions. Neither side determines the other.

The Power of a Framework

It would be tempting to think that this problem of balancing the economic, social, and cultural aspects of technology is an esoteric problem that should only concern experts. Only historians of technology need to worry about this in order to maintain the coherency of their discipline. One might think that is certainly not something that your average engineering student would want to read about in TWH. Yet, I think this is exactly what we need to be offering to our students.

Today, my engineering students--like most Americans--think that technology is largely about material abundance. Technology should produce more goods, more services, and above all, more information. More is somehow better, in the belief that markets will somehow distribute this increasing abundance in an appropriate fashion.

Although it is beyond the scope of this essay, my suspicion is that Americans came to equate technology with material abundance as they appropriated machines and ideas from the British during the Industrial Revolution. For much of the 17th and 18th centuries, the dominant political idea in Europe was that political order, the state, came first and everything should support the state--technology, religion, and culture. Just think of Louis XIV's famous dictum, "L'Ètat, c'est moi." In some ways, the French Revolution was a continuation of this dominant political idea, with the battle coming over who should control the state--the king and nobles or the people. However, during the late 18th century, some British merchants and industrialists began to articulate a truly revolutionary view: rather than political order being paramount, what was actually most important to them was material abundance (Uglow 2002). If a society concentrated on increasing its wealth via technological improvement, then the surplus could be used to produce social order and cultural meaning. What was revolutionary about the Industrial Revolution, then, was that the British and Americans came to believe that the good society would be achieved primarily through the creation of material abundance and that people should focus technology to produce abundance.

Yet technology is not just about material abundance, and my students know this, at least intuitively, when they see how technology enriches some people over others, alters the structure and habits of communities, and introduces new ideas and beliefs. This awareness is often caught in the shrug-of-the-shoulders and the throwaway line, "Well, that's progress." We Americans recognize that technology does provide progress in the sense of greater material abundance, but that the

pursuit of abundance does not always come with the social order and cultural meanings that we might desire. To me, one way out of this puzzle is to understand how civilizations--past and present--use technology to simultaneously pursue abundance, order, and meaning. Through a genuine global history of technology, we can see that different cultures have pursued different strategies, securing abundance along with order and meaning. If we can convey this basic lesson to our students, then we will have made an important start in helping them to understand "the impact of engineering solutions in a global and societal context."

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