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Technological Literacy and Empowerment: Exemplars from the History of Technology

As technological literacy takes form as a curriculum and field of study, we need to ask ourselves continually what we are trying to accomplish. Is our goal simply to teach students how things work so that they can be passive employees or consumers in a capitalist economy? Or could the goal of technological literacy be broader and more active--that we want our students not only to understand the machine but to comprehend how individuals, groups, and societies use technology to satisfy their needs and pursue their wishes and dreams? Do we want to provide students with ways of thinking about how technology can be shaped to serve a range of goals and values?

In this paper, I will advocate that we should strive to develop a technological literacy that embraces this broader and more activist perspective. I will suggest that this perspective can be included in technological literacy curricula by using themes and episodes from the history of technology and science-technology studies (STS) that illustrate how people used technology to achieve spiritual and political goals. To make my case, I will draw on a variety of examples, including the Shakers of nineteenth-century America, the first emperor of China, and fax machines in the Soviet Union. These examples are drawn from a larger project, *Technology in World History* [TWH], a seven-volume reference work which I edited for Oxford University Press.¹

But isn't technological change only about economic change?

In the course of teaching the history of technology for twenty years, I have noticed that students generally associate technological change with economic change—new products and processes are expected to enrich individuals, give companies a competitive advantage, and allow nations to prosper. Students are also aware that nations pursue technological innovation in order to gain a military advantage. But for the most part, students do not give much thought to how people use technology to achieve political, social or religious goals. I suspect that these student assumptions reflect the dualism prevalent in modern thought that separates the material world from the world of ideas; technology is about “stuff” and “stuff” is dealt with by markets and business while politics, society, and religion are the realm of beliefs, ideas, and abstractions, all of which are ethereal and not affected by material considerations.

Given that students tend to find it easy to think about technological and economic change and are less familiar with the interplay of technology and political power or religious beliefs, the examples offered here focus on themes relating first to religion and then politics. While there are other ways that people use technology to shape their lives and their culture, I have selected these themes and examples because they are provocative and would hopefully get students thinking and talking about how people use technology.

Theme 1: People use technology not only to pursue economic goals but also spiritual goals

To help students think about how people use technology to pursue noneconomic goals, I find it advantageous to use the Shakers as a case study. By looking at the Shakers, students can readily appreciate how people manifest their spiritual beliefs through technology.

In many ways, the Shakers represent what David Nye has called a "counternarrative" to the traditional story we tell about the Industrial Revolution in America.² In the decades leading up to the Civil War, new factories (such as those at Lowell), new machines (such as those used by Connecticut clockmakers), and new products (such as cheap clocks) dramatically changed American life. Far fewer Americans were entirely self-sufficient, able to produce their own food, clothing, and houses.³ Far more Americans now lived in towns, worked for wages, and the rhythm of their day was shaped by the factory bell. And Americans seemed more concerned with material gain than with the perfection of a new political order or with spiritual affairs. These changes troubled critics and reformers, leading Ralph Waldo Emerson to lament, "Things are in the saddle,/And ride mankind."

But not everyone simply accepted that "things" should rule people's lives. During the Industrial Revolution, several groups experimented with alternative ways of using technology to shape society. These experiments included both agricultural communities such as Brook Farm outside Boston where in the 1840s, several hundred people (including the author Nathaniel Hawthorne) lived and worked together. A more far-fetched scheme was the energy utopia proposed by the German immigrant, Johannes Etzler; Etzler believed that if all of the energy produced by waterfalls, the wind, the tides, and the sun could be harnessed, people would no longer have to work and could devote themselves to self-improvement.⁴ But of all the various movements that appeared in response to industrialization, the group that most effectively linked technology and society were the United Society of Believers in the First and Second Appearance of Christ, more commonly known as the Shakers.

The Shakers were founded by Mother Ann Lee (1736-1784), who grew up in the slums of Manchester, England and worked as a girl in the textile mills there. A devout and charismatic Quaker, Mother Ann became convinced that men and women could overcome the unhappiness and misery of the world by living together in equality and celibacy. In her view, everyone was equal regardless of gender, race, or age. Mother Ann's early followers, moved by the Spirit, often danced wildly during services, and hence were called Shakers. Persecuted for their unusual beliefs, Mother Ann and her followers emigrated to America, and settled in Niskeyena, just outside Albany, New York in 1776.

Although jailed in America for preaching, Mother Ann persevered, and by the time she died in 1784, she had attracted several hundred converts across New York and New England. Guided by Mother Ann's successors, Father Joseph Meacham and Mother Lucy Wright, these converts withdrew from the world and established their own communities. Between 1787 and 1836, the Shakers established nineteen villages from Maine to Kentucky. Within these communities, men and women lived as brothers and

sisters inspired by the ideals of love, community property, work, simplicity, and order. Their motto was "Put your hands to work, and your hearts to God."

The Shakers believed that everything around them should be a true reflection of the inner spirit. All of the virtues that were good for their souls--honesty, utility, simplicity, purity, order, precision, economy--should be part of the things they made and the way they lived each day. As one Shaker explained, "Heaven and Earth are threads of one loom." As a result, the Shakers laid out simple but wonderfully ordered villages, they built plain but elegant buildings, and they made remarkably useful and beautiful objects to use in daily life. Shaker villages and products stood in marked contrast to many of the goods of American industrialization whose design was driven by the limits of mechanization and the competitive forces of the marketplace.

For the Shakers, technology was not to be rejected but rather carefully shaped to advance their spiritual values. For instance, their desire for cleanliness in their dwelling houses led them to install rows of pegs along the walls so that chairs and other furnishings could be lifted up and the floor could be swept thoroughly. Their belief in order prompted them to craft beautiful built-in drawers, cupboards, and closets so that everything could be put away. Valuing the labor of each brother and sister, the Shakers designed labor-saving tools including the flat broom, the wooden clothespin, and the circular saw. Efficiency was reflected in the design of their barns. At their village in Hancock, Massachusetts, the Shakers built a great round stone barn; inside the floor spiraled upward so that the maximum number of cows could be brought in for milking. While the cows were being milked, the Shaker brothers could feed the cows by throwing hay from the loft down the barn's open central core. Because work was how they came to know and love God, the Shakers took great pride in their craftsmanship; even the backs of cupboards were beautifully finished, in the belief that God saw all parts of an object they made.

Attracted by the simplicity, order, and spirituality of the Shakers, people from all walks of life joined their communities. At their height in 1840, the Shakers had between 4000 and 6000 members. However, in the late nineteenth century, Shaker communities fell into decline. Some historians believe that celibacy discouraged many from joining, but it is just as likely that the strong emphasis on individualism in American culture after the Civil War discouraged people from participating in a communal experiment. Today, only two of the villages remain active, staffed by a handful of true believers. Yet buildings at many of the other Shaker villages have been converted into museums, and serve to remind Americans about how groups can shape technology to reflect spiritual goals.⁵

In terms of teaching technological literacy, the Shakers could, on one level, be used as a case study to talk about the technology of farming--what kind of machines and practices that Americans used through much of their history to put food on the table. On another level, the Shakers can be used to invite students to think about how people design artifacts to manifest deeply-held beliefs. The point to make with the Shakers is that technology is not just about economic matters; technology is also used by people to pursue spiritual goals.

Theme 2: Political power is manifested through technology

Once we have gotten students to consider how technology is about more than just economic change, it is then appropriate to get them to think about the relation between technology and political power. Long before nation states or corporations pursued new technology for economic ends, rulers employed technology in order to gain and hold political power.⁶ One of the best examples of this comes from the history of China.

In 221 BCE, a leader from the western Chinese state of Qin, Shihuangdi (259-210 BCE), unified China by conquering all of the rival warring states. A military innovator, Shihuangdi won battles not only by using new cavalry tactics but by establishing arsenals which used interchangeable parts to turn out thousands of crossbows quickly. Bringing to an end nearly four centuries of constant warfare, Shihuangdi declared himself the first emperor and boldly predicted that his successors would rule China for 10,000 generations.

But how should Shihuangdi consolidate his power and create a unified Chinese culture? Having achieved victory on the battlefield by using mass-produced crossbows, it is perhaps not surprising that Shihuangdi turned to technology. First, to protect the empire's Western border, Shihuangdi dispatched 300,000 workers to build the Great Wall. Next, to eliminate any future rivals from gaining too much power inside China, he abolished the old system of aristocratic fiefdoms and instead divided his empire into 36 districts, each headed by a civil governor, a military commander, and an imperial inspector. To permit his officials and troops to travel to the far-flung districts and enforce his rule, Shihuangdi built a network of roads radiating from his capital at Xianyang. To ensure that imperial pronouncements would be obeyed, Shihuangdi ordered that everything be standardized, including the law, language, taxes, weights, and measures. Not only did Shihuangdi issue standard copper coins with a square hole in the center, but he insisted that the axle width of all carts be uniform. Shihuangdi's engineers accomplished this by cutting ruts at the official width in the roads for the wheels of the carts. Shihuangdi understood well that technology could be used to demonstrate political power, and upon his death, he was buried in an elaborate tomb, guarded by 7000 life-size terra cotta soldiers.⁷

Shihuangdi's reign illustrates well one of the fundamental functions of technology—to manifest political power. Again and again, the Chinese people could look at the “things” created by the emperor and be reminded of his power—not only great monuments such as the Great Wall but also little things such as the official coins or the standardized ruts in the road. To be sure, Shihuangdi could have continued to use military power to control China, but a large standing army would have been costly and the aggressive use of force might well have provoked rebellion; it is far better and cheaper to exercise power through technological surrogates in the form of monuments, roads, and standards.⁸

Throughout history, other rulers and governments have done the same with technology, and obvious examples include the aqueducts, and civil engineering projects of the Romans or the space programs of the US, Russia, and the European community.

One of my favorite examples of using technology to illustrate power comes from Louis XIV and Versailles; scattered throughout the gardens are numerous large cast iron statues, and it was not lost on diplomats visiting from other European powers that if the King could commission so many iron statues, then France possessed the industrial capacity to produce an equal number of heavy cannon to use in war.⁹

I would suggest that in a course on technological literacy the instructor could include the Great Wall of China, the Roman aqueducts, or the gardens of Versailles as a case study. He or she could then use these cases as an opportunity for not only teaching how the technology worked but also how rulers in those cultures made technology work for them.

Theme 3: Political revolutions are often aided by new communications technologies

But just as rulers and governments seek to maintain the status quo by displays of technological power, so other technologies can be used to bring about regime change. In particular, the availability of new communications technologies often play a part in political revolutions, and a compelling example is how people used the fax machine in the fall of the Soviet Union in the late 1980s.

Throughout much of history, governments have long been aware that the free circulation of information and ideas can be a threat. During the *ancien regime* in France, newspapers were strictly controlled by the monarchy, and during the Nazi regime in Germany, only radios tuned to state-controlled stations were officially permitted. Likewise in the Soviet Union after World War II, photocopying machines were strictly controlled. According to one historian of technology, Jonathan Coopersmith, Soviet scientific institutes had to lock and seal rooms containing photocopiers to prevent illegal copying and distribution of information.

During the Soviet era, intellectuals and dissidents went to great lengths to distribute unofficial news, using hand-written carbon copies, cassette tapes, and even recycled x-ray plates that were converted into phonograph records.

However, under *glasnost* in the 1980s, Mikael Gorbachev relaxed the policies relating to communications technology. For the first time, small businesses and individuals were permitted to import photocopiers, and even more importantly, fax machines. Fax machines had a powerful effect on Russian society, allowing individuals around the country to circumvent the state-controlled media and share information. Dissidents in all parts of the Soviet Union were able to find out immediately what was going on and they were able to coordinate their efforts in protesting and demanding reform.

The growing number of fax machines in the Soviet Union stimulated the creation of a new news organization, Interfax. Founded in 1989 in Moscow, Interfax specialized in faxing news to customers around the Soviet Union. It established a reputation as being reliable and objective, and soon intellectuals, foreign journalists, and even Gorbachev's office came to depend on Interfax for information.

Interfax played an important role in the attempted coup of August 1991. During this coup, hard-line conservatives tried to take control, force Gorbachev to work with them, and stop Boris Yeltsin from continuing his reform program. The leaders of the coup made a number of blunders (such as assuming that Russian soldiers would be willing to follow orders and shoot Russian protesters), but the real mistake they made was not to cut the domestic and international telephone lines. Even though the coup forced Interfax to close its offices in Moscow, Yeltsin quickly offered it new office space and the organization was able to continue to transmit stories.

Significantly, Interfax sent stories to news organizations outside Russia--such as the Voice of America and the BBC--who then broadcast the stories back into the Soviet Union so that they could be heard by ordinary Russian citizens. Equally, the White House depended on Interfax and other fax messages in order to frame its policy toward Russia. As a result of being able to use fax machines to get their story out quickly, the opponents of the coup were able to prevail both at home and in the West.¹⁰

Thus, as Coopersmith has argued, fax machines contributed to fall of the Soviet Union because they helped dissidents to achieve two goals: first, to share information and organize their efforts internally, and second, to disseminate information about their position and gain legitimacy with groups outside the Soviet Union. While fax machines did not cause the fall of the Soviet Union, the important lesson here is that opponents of the Soviet regime skillfully employed this technology to undermine the status quo of the old regime.

While the story of fax machines and the fall of the Soviet Union is a clear example of how people can use communications technology to bring about political change, it is not the only example that we might use. If we look back in time, we can consider how Protestants in Europe used the invention of the printing press to spread new religious ideas in the sixteenth century. By printing thousands of copies of key religious pamphlets and Bibles in vernacular languages, they stimulated religious debate and political change.¹¹ A similar story can be told of woodblock printing in China; in order to produce thousands of copies of Buddhist texts in the ninth century CE, Buddhists developed the technique of carving each of page of text onto a separate block and then printing multiple copies.¹²

More recently, cell telephones have been used by groups to take political action. By sending text messages quickly to thousands of people, organizers can now create instant crowds which Howard Rheingold has dubbed "smart mobs."¹³ According to some reports, groups protesting at the 1999 meeting of the World Trade Organization in Seattle used cell phones to coordinate the movements of protesters and create swarms of people where they would have the greatest impact. Even more significant is the role played by cell phones in the downfall of President Joseph Estrada in the Philippines in January 2001. By texting messages such as "Wear black to mourn the death of democracy" and "Go to EDSA" (a major crossroads in Manila), Estrada's political opponents were able to bring together more than a million Filipinos for a mass demonstration. Gathered at EDSA, the crowd did not disperse for three days until Estrada had been replaced by a new President, Gloria Macapagal-Arroyo. To be sure,

Estrada's downfall was shaped by the fact that the Army and police withdrew their support and joined the crowds at EDSA and the change of leadership was hardly democratic, driven largely by the size of the mob gathered in Manila.¹⁴ Nevertheless, this episode again illustrates how the shrewd use of communications technology facilitated regime change. In teaching technological literacy, I suspect that our students would be fascinated to learn that a technology that they use everyday could be employed in such a powerful manner.

Theme 4: Communications technologies often involve a paradoxical mix of individual freedom and centralized authority

At first glance, these stories of fax machines and cell phones toppling political regimes may suggest a simple relationship between political and technological progress. By using modern, flexible communications technologies, individuals have been able to overcome the older, more ponderous technologies of the central state in order to advance freedom and democracy. The Great Wall of China is no match for text messaging and the World Wide Web. Telecommunications and digital technology will set us free!

But before drawing this rosy conclusion with our students, we need to look more closely at how technologies such as fax machines, cell phones, or the Internet actually work. These technologies embody a paradox because individual convenience and freedom is only attained by the involvement of large-scale organizations or bureaucracy. All of these technologies, whether wired or wireless, require some sort of network--a group of links such as phone lines, satellites, microwave towers, or computer servers. To build and maintain these links--this infrastructure--is expensive, making network technologies fundamentally capital-intensive.

Moreover, network technologies only work if there is some sort of coordination via shared standards. As Coopersmith has argued, fax machines only became widespread when the International Telecommunications Union established protocols that allowed fax machines produced by different manufacturers to talk with one another.¹⁵ Likewise, the World Wide Web depends entirely on the use of standard addresses (url) and a universal mark-up language (html) so that a web page produced by a person on one side of the world can be downloaded and viewed by someone on the other side of the planet. Without standards, it would not be possible to surf the Web, and the World Wide Web would soon go the way of the mythic Tower of Babel.

For network technologies to work then, people need to invest large amounts of capital and figure out ways to provide the necessary coordination and standards. To accomplish these tasks, the people building network technologies--whether it be telegraph, telephone, radio, television, or computers--have had to work with large-scale organizations. In America, the historical tradition has been to rely generally on private corporations to raise the necessary capital and create the bureaucracy needed to operate the network. One example of this is the rise of Western Union in the 1870s; only by creating a single nationwide network was it possible to make the telegraph efficient and profitable and hence be able to convince Wall Street to invest heavily in this new technology. A similar story can be told of Microsoft in the 1990s; Microsoft proponents

would argue that personal computers only became practical and profitable when they shared a common operating system, and the only way to create a reliable and innovative operating system was to do it within the confines of a single company. Only within a corporation can managers exercise the necessary control over the process of writing software that ensures a good product. (Of course, advocates for Open Source and Linux would claim that they created a global social network that permitted them to write equally good, if not superior, software.)

But as history also shows, some network technologies were so capital-intensive or so difficult to control that they required the involvement of the state. While the American telegraph network was built by largely using private capital, European telegraph systems were in contrast built and managed by national governments. Equally, as radio technology began to be used in America in the early 1900s by a mix of amateurs, companies, and the Navy, there was a great deal of interference and fighting among the groups for who would get to use airwaves. This conflict prompted the federal government to step in and, through regulation, allocate the electromagnetic spectrum to different needs and different groups.¹⁶

The point, here, then, is that network technologies embody a fundamental tension: to achieve widespread, low-cost benefits for individuals, one needs to build and maintain a centralized network. In order to provide information and convenience to individuals, one needs to mobilize capital and coordinate the links of the network, and these two tasks are generally done by large organizations such as corporations or the state. Hence, while network technologies such as cell phones can be used to challenge and bring down political regimes, these technologies only function if individuals are willing to cede power to other centralized organizations.

In my view, Americans have dealt with this paradox by doing two things. On the one hand, they have embraced a rhetoric of technological change that highlights the benefits to the individual. Over the past two centuries, Americans have greeted the development of each new communications technology as a means of empowering the individual and advancing democratic values. With the telegraph in the 1840s, the telephone in the 1870s, broadcast radio in the 1920s, or email in the 1990s, Americans claimed that these inventions would further democratic civilization by providing individuals with more information so that they could be more effective voters and economic actors. They also felt that by being able to be in contact with each other, the technology would foster new social ties and a sense of community.¹⁷

On the other hand, as they embraced new communications technologies, Americans have downplayed, and for the most part, ignored the centralized infrastructure that these technologies required. Drawing on their faith in the competitive marketplace and in the rational objectivity of science, Americans in the twentieth century conceded that the messy business of building and running these networks should be left to experts working for either corporations or the government. Some combination of marketplace competition and the inexorable logic of science would lead managers and engineers to "do the right thing" in terms of running these networks on our behalf.

Yet there is no guarantee that some combination of competition and science will give us the freedom and convenience we desire without having to pay too high a price in terms of centralized authority. While experts are often necessary for modern technology, their actions in a democracy must be guided by an informed citizenry. In order to guide the experts and ensure that a technology strikes the right balance between individual freedom and centralized authority, citizens need to understand not only how the technology works mechanically and electrically but something about the organizations that undergird it as well.

Concluding Remarks

Reflecting on these different themes and examples, I hope you will be provoked into thinking about what we mean by technological literacy. Drawing on the case of cell phones for one last time, is someone technologically literate if

- they can make a call on a cell phone?
- they are able to tell you what happens inside a cell phone?
- they can say something about the technical network--how the standards, the cells, and microwave towers fit together?
- they can talk about how cell phones deliver individual convenience because users agree to cooperate with a larger centralized bureaucracy?¹⁸

I would argue that modern society--particularly a democratic society--needs individuals who possess technological literacy on all these levels. It is not enough to know how to use a cell phone or even what is happening in the electronic circuits inside the phone; that knowledge is really only useful if one understands something about the network in which the phone operates and about the social and political forces that shape the network.

This broader understanding of technology is essential if we want to live in a democracy, in the sense that we exercise choices about who is in control of the technology and about which technologies we choose to use in our lives. Without a broader understanding of the interplay of technology and political power, we will lose the ability to use technology to bring about genuine political change as the Russian people did with fax machines. Even more worrisome, without a broader understanding of technology and power, we run the very real risk that modern technology will be used solely for control, much as Shihuangdi did in ancient China.

I know that there may be some resistance to this broader notion of technological literacy. I can anticipate that some people will say that it takes one type of expert--an engineer or scientist--to explain the inner workings of the machine to students and they don't necessarily know how to teach about the political, economic, or religious contexts of technology. To teach the contexts of technology is the job of other experts, historians and social scientists, and we should just trust that (a) students will get around to taking courses with those experts and (b) that history and social science courses will actually cover technology. Knowing that (a) and (b) are both not likely to happen, I would suggest

that those of us shaping technological literacy need to recognize now that the only way to teach this broader form of technological literacy is to work together to create materials that integrate how the machine works with how people use the machine. Engineers, historians of technology, and STS scholars must collaborate to create case studies that will teach students not only technical principles but also empower them to use technology to change the world. That's what technological literacy can--and should--do.

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