CULTURAL IMPACTS OF TECHNOLOGY

Technology profoundly affects modern life. Exclamations about the role of computers, automobiles, airplanes, communications, and a hundred other machines and systems are omnipresent in the popular press. Nonetheless, the question of technology's impact on culture is a thorny one, not because of any doubts about the importance of technology, but rather because of philosophical problems raised by the notion of impact. Technology and culture (if they are separable at all) profoundly interact, indeed define each other; and hence *impact* is an imperfect metaphor.

Consider, for example, the notion of an environmental impact statement. Such a document maintains the distinction between human products, such as factories and highways, and the nontechnological environment. Speaking about the social or cultural impacts of technology similarly implies an assumption about technology and culture: that the two are separate, independent entities. *Technology,* by conventional definition, stands for the constellation of machinery, systems, and techniques that manipulate the natural world for human ends. In contrast, *culture* here would encompass numerous human activities, from wedding ceremonies to political rituals to musical performances to ethnic identity. In such a scheme, *culture* refers to everything else that is not technology. Speaking of cultural impacts, then, suggests that technology is somehow outside of culture, perhaps even outside of human direction, and impacts human beings and their society as an external force.

If technology is outside of culture, then it follows that technology proceeds autonomously, propelled by its own internal logic independent of cultural influences. Scholars today call this notion "technological determinism" (1). It is unquestionably the dominant mode in popular discourse of technology today, expressed in pronouncements on everything from the nuclear arms race to the irresistible march of Moore's law. A number of corollaries follow from the deterministic worldview. For example, theories about the phenomenon of cultural lag, in vogue in the decades after the atomic bomb, declared that our technical abilities outstripped our moral and cultural capacities for dealing with the impacts. Stating the theory in this way stems from a deterministic model that argues that culture needs to keep up with technological change as it proceeds at its own feverish pace. Again, the theory implies that the two are somehow separable, technology ahead of culture.

Another corollary to technological determinism states that if technology proceeds by its own logic, then human attempts to shape technological progress amount to interfering with an otherwise natural force. In a deterministic worldview, any attempts to alter the direction of technological change (for political, social, or environmental reasons, for example) are automatically seen as resistance. The story of the development of technology, then, becomes one of foreordained progress (frequently merely "discovered" by heroic inventors) overcoming irrational human resistance. Debate over technologies thus becomes polarized into opposing camps of technocrats, accused of promoting technology for its own sake, and luddites, accused of wanting to send us back to the dark ages. Framed in this way, neither side has much to say to each other, and productive debate becomes scarce.

At the root of these difficulties (usually unexamined by either side) lie philosophical and historical problems with technological determinism. As early as 1934, Lewis Mumford, in his seminal work *Technics and Civilization,* showed that technology results from cultural phenomena as much as impacts them. "Men became mechanical," Mumford wrote, "before they perfected complicated machines to express their new

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bent and interest; and the will-to-order had appeared once more in the monastery and the army and the counting-house before it finally manifested itself in the factory" (2). Mumford saw machines as cultural projects, expressions of human fears and ambitions as much as any painting or sculpture. Hence the culture of technology became a rich field for investigating and elucidating human aspirations.

Since Mumford, numerous scholars have supported, expanded, and refined this approach. A broad variety of studies today show that technologies develop in response to numerous forces—social, economic, political, aesthetic—as well as technical. For example, electric lighting appealed to the public as a powerful symbolic medium as much as an incarnation of useful science. For most Americans around the turn of the nineteenth century, electric light was a dreamlike experience of public urban space before it became a domestic utility (3). In addition, military technologies have always built on the imaginative schemas of future warfare, often delineated earliest and most clearly by literary writers. Jules Verne's vision of life beneath the seas (itself building on naval technologies of the day) inspired generations of submarine engineers. Similarly, the modern "top fuel" dragster emerged in its present form (i.e., nitromethane-burning engine in the rear, large stubby rear tires, driver in front of the engine, long nose with bicycle-type front tires) not just as an optimal technical solution but as an optimal theatrical solution as well. The sport needed to retain audiences to pay for itself, so designs were selected for high performance in both the technical and theatrical sense of the term (4). Need we add that the term *cyberspace,* hallmark metaphor of today's technological age, was coined by a science fiction writer (William Gibson in his 1984 cyberpunk classic, *Neuromancer*) (5) and not by an engineer? In none of these cases do technologies unilaterally impact culture.

As a more detailed example, consider a recent study of the development of inertial guidance technology during the Cold War. Author Donald MacKenzie examined what had been presented as a natural trajectory of progress in intercontinental ballistic missiles—that is, that the accuracy of missile systems naturally increased over time. Proponents of inertial guidance, MacKenzie found, selectively adopted and discarded their claim that the technology was "most accurate," depending on their opponents at any given time. When inertial guidance was compared to other technologies, any number of other characteristics would emerge as top priority in design, including reliability, immunity from jamming, and ease of calibration, depending on the characteristics of competing technical solutions (e.g., radio guidance, stellar guidance). Nonetheless, proponents of inertial guidance, looking back, presented the technology as progressing along a deterministic curve of ever-increasing accuracy—a supposedly autonomous path that then impacted culture in the form of military contracts, nuclear strategy, and Cold War politics. MacKenzie shows, however, that if such a trajectory had truly been the paramount concern at the time, guidance engineers would have made different technical choices. The natural trajectory then, suggesting autonomous progress, was the retrospective account of a group interested in ratifying its own approach as the only correct one. It was the history of the victors or, as MacKenzie calls it, a self-fulfilling prophecy (6).

One could imagine a similar analysis for the so-called natural trajectory of Moore's law, which states that the density of transistors on chips doubles every 18 months. Rather than increasing on its own, however, progress in chips is the result of a fabric of human decisions on a broad range of topics ranging from packaging and testing to architecture and optics. As with the case of inertial guidance, the trajectory is promoted as "natural" by those whose interests will benefit from a certain path for the technology, and by those (often the press) who uncritically accept those claims. Because people in the industry take Moore's law as a given, they plan their technologies according to its schedule and the prophecy fulfills itself through such decisions. In this case, the culture of semiconductors (including design engineers, strategic planners, equipment manufacturers, basic scientists, and customers) and the technology (chips, equipment, motherboards, personal computers) constitute each other.

This integrated approach to technology and culture, despite its variety of players, does not downgrade the role of engineers to mere slaves of social forces. In fact, this perspective actually underscores engineers' creativity by emphasizing the numerous degrees of freedom in their work. If technology proceeds autonomously, then the work of individuals is irrelevant to the process. Seeing technology and culture as intertwined, however, emphasizes the importance of human contributions. Engineers, while strictly constrained by natural phenomena such as the properties of materials and the laws of physics, can still build bridges, airplanes, and even computers in a wide variety of ways. Which designs succeed result from numerous factors in the design process, including physical and technical realities, but also judgment, experience, and values. Thus values in the design process—which might be as varied as efficiency, gigantism, simplicity, and beauty—are not unnecessary external variables but integral components of the technology that help determine success or failure. How often do we hear of a company succeeding or failing because of its unique culture?

Is it impossible, then, to discuss rigorously the cultural impacts of technology? One simple corrective is to replace the term *impact* with *implications,* a term with similar connotations but that does not assume a dichotomous separation of the two entities. A more interesting approach, however, with similar but arguably stronger results, opens the black box of technological change, to try to understand with precision the simultaneous social *and* cultural dynamics of technical development. New questions include the following: How exactly do engineers embody values into their designs (remembering that neutrality and disinterestedness are themselves values)? How do others take up technologies designed with certain values and use them for other purposes? How does technological knowledge reside in local cultures, of laboratories, of companies, or of industrial regions? Understanding technology in this way will go a long way toward demystifying the otherwise magical march of technology and highlighting the human role in making choices about technologies. Thus freed from circular debates between enthusiasts and luddites, we are more likely to understand the human potential to direct technological change toward favorable ends, whatever they might be.

BIBLIOGRAPHY

1. M. R. Smith and L. Marx (eds.), *Does Technology Drive History?: The Dilemma of Technological Determinism,* Cambridge, MA: MIT Press, 1994.

2. L. Mumford, *Technics and Civilization,* New York: Harcourt Brace Javonovitch, 1934.
3. D. Nye, *Electrifying America: Social Meanings of a New Technology,* Cambridge, MA: MIT Press, 1990, p. 382.
4. R. C. Post, *High Performance: The Culture and Technology of Drag Racing: 1950–1990,* Baltimore: Johns Hopkins University Press, 1994.
5. W. Gibson, *Neruomancer,* New York: Ace Books, 1984.
6. D. MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance,* Cambridge, MA: MIT Press, 1990.

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