TECHNOLOGY TRANSFER AND DIFFUSION

Kenneth L. Nichols
University of Maine, USA

Keywords: technology, technology dissemination, technology transfer, technology diffusion, innovation, dissemination, transfer, diffusion

Contents

Summary

Technology transfer and diffusion are two aspects of *technology dissemination*, which is the process by which innovations are transmitted from donor to receiver. *Technology*

transfer involves communication between a specific donor and a specific recipient or group of recipients. In *technology diffusion*, the donor is not necessarily aware of who the recipients may be. Technology itself can take the form of an object ("material technology") or a concept or technique ("social technology"). Technology transfer is a major component of international policy — military policy, trade policy, and humanitarian policy are three spheres in which it operates. Consequently, both as an abstract and mechanical process and as an aspect of conscious and unconscious policy, technology transfer and diffusion are fundamental mechanisms of human life support systems. This article examines technology dissemination in terms of its roots, the processes and actors involved, relevant policy and practice, and ramifications for the future.

1. The Beginnings of Technology Dissemination

Technology transfer and diffusion predate recorded history. As long as humans have had the intelligence to observe, use tools, and learn from one another, humans have practiced technology dissemination. Flaking flint shards from a rock to use as a cutting device, working in groups to hunt game, and collecting particular seeds to scatter for another harvest—all are technology innovations widely used by prehistoric peoples.

1.1 Technology: Multiple Definitions

Whether through transfer or diffusion, technology dissemination is a process that involves moving an innovation from one party to another. *Technology* is a noun—a term that holds several levels of meaning. The broadest and most fundamental definition of technology is *whatever civilization uses to sustain itself.*
Within this definition, manufactured objects (e.g. pottery and baskets) and objects adapted from nature (e.g. herbal medicines) are known as *material technologies*. Processes, techniques, and other types of applied knowledge (e.g. double-entry bookkeeping) are known as intangible or *social technologies*. Technologies can be grouped into basic categories:

- languages and codes, whether spoken, written, or signed;
- customs, traditions, rituals, and rites;
- applied concepts and knowledge;
- natural objects that people put to use;
- manufactured tools and other goods;
- performances and objects valued for aesthetic or symbolic reasons.

1.1.1 Languages and Codes

Humans are born with an innate, hard-wired capacity to learn and communicate though spoken language. Nevertheless, the languages humans create, use, and modify over time are inventions; people concoct and disseminate those inventions to express themselves and understand others. That makes language itself a technology.

Language involves gestures and expressions as well as sounds. Meanings that stem from particular sounds, expressions, and gestures may initially have been based on

onomatopoeia—that is, the approximation of a natural sound or movement such as the "whoosh" of a sudden breeze—or on instinctive behaviors such as the "ahh" triggered by an unexpectedly pleasant experience. Those initial elements of language are transformed and expanded, continuously adapting a language to new needs and situations.

Usually, the transformation is minor and unconscious, though sometimes—such as with Esperanto and American Sign Language—it is not. *Written* language is itself a consciously-crafted invention distinct from the spoken language itself. Hand-signing is another direct, nonverbal translation of spoken language.

Unlike spoken language, *codes* are more clearly and consciously invented. A code is the assignment of meanings to an arbitrary set of signs or symbols. Morse Code for telegraphy and signal flags for ship-to-ship communication are two such examples. Some codes facilitate secrecy by aiding communication between selected parties while excluding others. These may be codes used in espionage and wartime (e.g. the enigma codes of World War II), but they may also apply to recreational and other purposes (e.g. signals between the catcher and pitcher in a baseball game, anagram puzzles in a newspaper).

Languages and codes are social technologies.

1.1.2 Customs, Traditions, Rituals, and Rites

Customs and *traditions* are habits or conventions so embedded in a culture that they may take on the force of law. Sometimes they may become the basis for a law (e.g. driving on a particular side of the road). They encompass behaviors and practices maintained from one generation to another. They can be so woven into a culture that people follow them without conscious thought.

Rituals and *rites* involve ceremonies and practices that are consciously performed. They may be small events, such as a bow or handshake when greeting someone, or they may be extended and elaborate, such as a wedding ceremony or funeral.

By their nature, customs, traditions, rituals, and rites evolve slowly. They are important social technologies a society uses to manage itself.

1.1.3 Applied Concepts and Knowledge

Applied knowledge and concepts form the operational foundation for every society. This broad category of social technologies encompasses everything from knowledge of assaying minerals to voting, and from international trade embargos to using role-play as an instructional technique.

Applied knowledge has a stratified structure: Some strata are subject to rapid change (e.g. surgical techniques), some strata change only modestly with time (e.g. rules of commerce), and some strata alter at a glacial pace (e.g. how people train their pets).

Does theoretical knowledge fit the definition of "technology"? No, only when put to use does knowledge become technology. Nuclear physics offers a classic example: Scientific understanding about how atoms are structured—and about what happens when the protons and neutrons in an atomic nucleus are split—moved from basic knowledge to applied knowledge when Enrico Fermi and others began to experiment with devices that *used* that knowledge. Nuclear weapons and nuclear power generation are fruits of that application of knowledge.

1.1.4 Manufactured Goods and Tools

Ice cream, automobiles, crayons, and super computers are all examples of manufactured goods and tools. This category of technology encompasses:

- highly sophisticated material technologies (e.g. communications satellites);
- traditional manufacturing output (e.g. automobiles, homes, refrigerators);
- high-tech toys (e.g. laser pointers; dolls that repeat what someone says);
- commonplace implements (shoes, spoons).

In everyday conversation, people tend to equate the term "technology" with the first and third of these subcategories. Highly sophisticated technologies are frequently a function of military and national security applications, such as surveillance satellites and weapons systems, and of scientific endeavors such as undersea and space exploration.

High-tech toys tend to be luxury consumer items such as cellular telephones, disc players, and automobile radar detectors. That usage notwithstanding, mundane gadgetry and traditional manufacturing are mainstay technologies essential to contemporary society.

1.1.5 Natural Objects Adapted for Use

Long before humans built material technology from scratch, they adapted objects from nature as tools of survival. Thatch, mud, and stones became building materials. Sticks and rocks were refashioned into weapons and hunting implements. Foliage and hides became clothing. Controlled fire became a device used for light, heat, cooking, and protection.

That tradition continues; in fact, it has enjoyed a resurgence. Tree stumps become table bases. Rocks turn into bookends. Salt continues to serve as a cleansing and curing agent. Water remains the universal solvent.

Food, which has always come from nature, continues to do so. What has changed is the level of adaptation: It has increased. Today, fish and vegetables can be quick-frozen, dairy products can be dried and powdered, fruit juices can be concentrated and then reconstituted, and almost any food product can be vacuum packed and fortified with additional nutrients. The search to identify natural medicines has also become significant.

1.1.6 Aesthetic Objects and Performances

People employ social and material technologies for pleasure as well as for productive purposes. Many natural and manufactured objects are prized solely for their aesthetic value. Examples of material technologies include carvings, paintings, jewelry, tattoos, gardens, and even stuffed animals. Examples of social technologies include opera, chess, crossword puzzles, soccer, barn dances, and animated cartoons.

The six categories of technology are not exclusive. From religion, for example, a high mass involves both ritual and aesthetic performance. A diamond can be found in nature and can also be manufactured. Animated cartoons embody aspects of both social and material technologies.

Moreover, the array of social technologies involved in exploring, developing, using, and preserving the planet's life support systems is huge and may well exceed the range of material technologies, however vast. This broad definition of technology forms the basis for discussing technology transfer and diffusion.

1.2 Impact on Societies

Technology dissemination affects societies in terms of the degree or *level* of impact (breadth, depth, and speed of dissemination) and the *nature* of that impact (benefit and surprise).

1.2.1 Level of Impact

Breadth involves the number of sectors touched and the number of people touched. A. sector could refer to a geographic area—a neighborhood, a community, a region, a nation, or beyond. A sector could equally refer to an economic or demographic component of society—older persons or a particular industry, for example. A consideration of breadth ultimately reflects the number of people affected. *Depth* involves the initial intensity of the touch, which could be subtle or startling, and to the long-term level of impact on the society. *Speed* of dissemination pertains to the rapidity with which a technological innovation spreads.

-
-
-

Bibliography

Aguayo, R. (1990). *Dr. Deming: The American Who Taught the Japanese About Quality*. New York: Fireside. [Biography of W. Edwards Deming detailing the emergence of statistical quality control and total quality management in the United States, their transfer through Deming to Japan, and their dissemination back to the U.S. and elsewhere.]

Bijker, W.E, Hughes T.P., and Pinch T.; eds., (1987). *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology.* Cambridge, Massachusetts: MIT Press. [Essays examining the influence of society on technology from the fifteenth century to current times.]

Burke, J. (1978). *Connections.* Boston: Little, Brown. [Popular book and television series exploring the intertwining of technology and society.]

Ciciotti, E., Alderman N., and Thwaites A., eds., (1990). *Technological Change in a Spatial Context: Theory, Empirical Evidence, and Policy.* New York: Springer-Verlag. [Examines technology-based change and policy on a range of spatial scales, from cities to global regions.]

Emery, F.E., and Trist, E.L. (1973) "The Causal Texture of Organizational Environments." *Tomorrow's Organizations: Challenges and Strategies*, J. S. Jun and W. B. Storm, eds. Glenview, Illinois: Scott, Foresman. [Systems approach to classifying turbulence levels for environments in which dissemination may or may not take place.]

Havelock, R.G., (1969). *Planning for Innovation through Dissemination and Utilization of Knowledge.* Ann Arbor: Institute for Social Research. [Landmark text on the dissemination of knowledge, including a model of research, development, and diffusion.]

Human Genome Project. [Background and status information are available to the public through Internet sources from the United States Department of Energy, Office of Science, at http://www.doegenomes.org/; also from the Sanger Institute in Great Britain at http://www.sanger.ac.uk/HGP/.]

Inkster, I. (1991). *Science and Technology in History: An Approach to Industrial Development.* New Brunswick, New Jersey: Rutgers University Press. [Traces the roles of institutions and technology in the industrial development, beginning in the eighteenth century, of Europe and its eastern trading partners.]

Kuhn, T.S, (1970). *The Structure of Scientific Revolutions*, 2nd ed. Chicago: University of Chicago Press. [Rethinks the process of disseminating, resisting, and adopting scientific premises that underlie much technology development.]

Marcus, A.I., and Segal H.P. (1999). *Technology in America: A Brief History*, 2nd ed. Fort Worth: Harcourt Brace. [A compact history of technology in America from the early fifteenth century forward, concentrating on the impact of American society and culture on technology.]

Mumford, L. (1967). *The Myth of the Machine: Technics and Human Development.* New York: Harcourt Brace Jovanovich. [Classic exposition on forces shaping technology since prehistoric times.]

Rogers, E.M. (2003). *Diffusion of Innovations*, 5th ed. New York: Free Press. [Classic text on innovation diffusion, establishing solid theoretical framework.]

Shepard, H.A. (1967). "Innovation-resisting and Innovation-producing Organizations." *Journal of Business* (October): 470-477. [Analysis of the role organizations have in shaping and disseminating technology.]

U.S., Department of Commerce, Technology Administration (TA) and Bureau of Industry and Security (BIS). [TA promotes innovation and standards (http://www.technology.gov/); BIS regulates U.S. exports for national security, foreign policy, and nonproliferation reasons (http://www.bis.doc.gov/complianceandenforcement/).]

Weisman, A. (1998). *Gaviotas: A Village to Reinvent the World.* White River Junction, Vermont: Chelsea Green Publishing Company. [Case study of technology transfer to a Colombian village.]

Williams, F., and Gibson D.V., eds., (1990). *Technology Transfer: A Communication Perspective.* Newbury Park, California: Sage. [Considers the role in technology transfer of communications media, organizations, universities, government, and industry.]

Biographical Sketch

Kenneth L. Nichols is associate professor of public policy and administration at the University of Maine. He is in the Department of Public Administration, since 1996.

Education

Professor Nichols earned his D.P.A. from George Mason University in 1993. He earned his M.P.A. from

George Mason in 1983 and his B.A. cum laude in English Language and Literature from Weber State University in 1968.

Professor Nichols co-edited Enterprise Government: Franchising and Cross-Servicing for Administrative Support, and his articles have appeared in popular as well as professional publications, including the Journal of Public Affairs Education, Public Administration Quarterly, Public Voices, and the International Encyclopedia of Public Policy and Administration. His forthcoming textbook is The Unreal Administrator: Lessons and Challenges from Poems, Novels, Movies, Television and Other Stuff.

Professor Nichols has been an adjunct instructor at George Mason University and, earlier, at the University of North Florida.

Service

Professor Nichols is former director of graduate programs for the University's Department of Public Administration and former chair of the Orono Public Library Board of Trustees. He is actively involved with the American Society for Public Administration and the World Future Society.

Formerly with the Internal Revenue Service, his professional work as a carer civil servant centered on emerging and innovative aspects of organizational activity. His responsibilities at the IRS included budget planning and program analysis, trend assessment and strategic planning, quality management, legislation development and implementation, information systems design, and large-scale organization reengineering.