

Visions of STS

Counterpoints in Science, Technology, and Society

Edited by Stephen H. Cutcliffe and Carl Mitcham

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Visions of STS brings together the views of ten leading scholars to clarify the nature of Science, Technology, and Society Studies and point toward future developments. The interdisciplinary field of STS maps out the interconnected relationships among science, technology, and society in order to better understand both the innumerable benefits as well as problematic challenges. This book, rather than presenting science and technology as autonomous entities, analyzes each contextually as societal-mediated processes that reflect cultural, political, and economic values. It contains four basic programmatic essays that deal with technological determinism, the social constructivist view, STS and policy information, and the issue of interdisciplinarity. *Visions of STS* also stresses more specialized perspectives of work, education, and public policy analysis, and challenges the way STS itself is pursued. Taken together, these essays offer an exciting and unusually broad overview of STS.

"This is a strong survey of the field of STS. It covers a lot of ground in ten concise essays that are accessible to non-experts in the field, yet detailed and provocative enough to hold the attention of the more advanced reader."

— Joseph R. Herkert, editor of *Social, Ethical, and Policy Implications of Engineering: Selected Readings*

"The book is useful, in relatively specific terms (e.g., on the issue of technological determinism) in helping any reader think about the relationships of science, technology, and society. It is also useful in broader terms for those working in and thinking about STS as a field."

— Jesse S. Tatum, author of *Energy Possibilities: Rethinking Alternatives and the Choice-Making Process*

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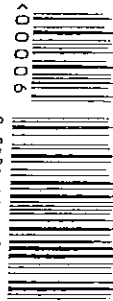
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Three Perspectives in STS in the Policy Context

LARS FUGLSANG

Lars Fuglsang teaches science and technology policy studies at Roskilde University in Denmark, a country that has developed a strong tradition of public participation in technology assessment. He is the author of *Technology and New Institutions: A Comparison of Strategic Choices and Technology Studies in the United States, Denmark, and Sweden* (1993), which argues that technology studies is a mosaic of approaches, rather than one singular method.

In the present essay, Fuglsang defends what he terms the "interactive" view of the STS relationship. In this view—to which the research of Bijker and other social constructivist scholars has contributed—science, technology, and society are seen as interrelated parts of a "seamless web," rather than as separate entities accidentally joined. He contrasts this more holistic or interactionist view with the depiction of science and technology as deterministic forces of socioeconomic change, and the idea that social forces are the shapers of science and technology. For Fuglsang, the arrow of determination is not one-way in either direction. While the notion of two interacting arrows may seem incongruous and in apparent conflict, Fuglsang argues that, in fact, they are really more representative of different phases of techno-scientific development in which science and technology can display both flexibility and inflexibility.

Thus, for Fuglsang, it is important to recognize how different STS perspectives may be appropriate to different stages of technological development. It is in the earliest stages of development that most technologies retain the most flexibility, so that the arrow of influence moves from society to technology. In later stages technologies become more entrenched, and the arrow of influence can move back the other way. In reading Fuglsang's essay, we may thus ask ourselves whether Fuglsang provides a way to harmonize the arguments for technological determinism found in Winner with the more constructivist approach to technology studies found in Bijker.

We might also consider, however, whether such a conceptual harmonization is sufficient to the challenge of the social control of technology. David Collingridge (1980), for instance, argued that there is a fundamental paradox for any attempt to control technology; that is, early in the development of any technology, when it is relatively easy to exercise some influence over it, we seldom know enough to actually do so, but once the technology has been socially deployed and we know enough about its negative consequences to want to control it, it has become rather difficult to do so. Does Fuglsang provide any way to deal with such a dilemma?

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In this essay I want to distinguish among what I view as three main perspectives in STS regarding science and technology and their relation to society. These three perspectives are: 1) science and technology shape society; 2) society shapes science and technology; and 3) an interactive view of the science, technology, and society relationship. Each of these perspectives developed over the course of a ten- to twenty-year period after World War II, and each is tied to a specific policy context. However, they can also be seen as simultaneous perspectives that have been competing with one another during the past fifty years. For present purposes, however, I treat them historically in the policy context.

Science and Technology Shape Society

This perspective evolved out of an optimistic atmosphere of science and technology in the years after World War II. Science and technology were, for the first time in modern history, considered as forces of socioeconomic change that made a difference for society and the economy.

One important contribution to this perspective was made by Vannevar Bush, the U.S. president's advisor for scientific research and development. His 1945 report, "Science, the Endless Frontier," is a source of inspiration for the modern funding system for science. Bush argued for a "basic science" which would eventually have positive consequences for the economy. In his vision, science should not be targeted directly by the government; rather, funding should be determined by scientists themselves through a system of peer review.

In this, Bush agreed with other authors of the time. During the 1930s, the British scientist John Desmond Bernal had already argued for science as a cornerstone in the building of modern society (1939). He also believed that science should be protected from direct external interference by society. Such considerations were also important for Derek de Solla Price (1963), one of the founding fathers of science studies. De Solla Price wanted to create a "science of science" that could lead to improvements of science institutions.

Arguments about the important role of science and technology were also, directly or indirectly, given by the Nobel Prize Laureates in economics Kenneth Arrow (1962) and Robert M. Solow (1956). Arrow argued that science needs public support because it is associated with economic risk (market failure). Thus, according to Arrow, science is characterized by its fundamental "uncertainty" (its results cannot be predicted), its "indivisibility" among economic actors (it cannot be divided among them like a cake), and its difficulty to be "appropriated" economically (since knowledge easily flows from one actor to another—the imitation problem). The existence of high economic risk, he argued, implies underinvestment in science by private firms, thus providing a rationale for public support.

Solow was investigating growth in output per worker in the U.S. in the period from 1909 to 1949. He found that 87.5 percent of the growth could not be explained by an increase in capital per worker as was usual, but had to be assigned a residual factor he called "technology." This was not very convenient, since economic theory had not generally treated technology in these models. Nonetheless, the argument suited the spirit of the time well—that science and technology were forces contributing to growth and prosperity.

Another variant of the "science and technology shape society" approach emerged from economic-historical theories. This variant

has its origin in the work of the Russian economist N.D. Kondratiev (1935) who found statistical evidence for long-term economic cycles of forty-five to sixty years in the period from the eighteenth century through to the 1920s in the U.S., U.K., and France. Building on Kondratiev's work, the Austrian economist Joseph Schumpeter attempted to explain the upswings and downswings in the economy with entrepreneurship and innovation. Entrepreneurs played, according to Schumpeter (1939), a creative-destructive role for economic recovery. Extending these arguments, Christopher Freeman and Carlotta Perez (1988) have put forward the idea that economic and institutional development is motivated by shifts in techno-economic paradigms, each containing a new key technology, such as the steam engine (late eighteenth century), railways (mid-nineteenth century), electricity (late nineteenth century), petrochemicals (early twentieth century), and information technology (mid-twentieth century).

This is a fairly broad but attractive approach that nicely chains together economic analysis with sociology and history. Similar ideas have been developed by Giovanni Dosi (1982), who argues that technology within each techno-economic paradigm evolves along certain trajectories (defined as "the pattern of 'normal' problem-solving activity [i.e., of progress]"). One example is the trajectory of semiconductors leading toward smaller, cheaper, more reliable, higher memory computer chips.

The "science and technology shapes society" approach also comprises more pessimistic views, such as those proposed by the French sociologist/philosopher Jacques Ellul (1964) or the German philosopher Jürgen Habermas (1973). Here, in an emerging tradition of "philosophy of technology," focus is on the alienating effects of science and technology on human life or other philosophical aspects of science and technology. Science and technology inform an instrumental rationality or a technological regime that overshadows and represses other equally important aspects of human life, such as philosophical or religious thought. The approach can be seen as a sophisticated historical-philosophical critique of civilization—one which is also elaborated by authors more directly linked with STS, such as Lewis Mumford (1967, 1970) and Langdon Winner (1986).

The "science and technology shapes society" perspective is sometimes labeled a "technological determinist approach." This can be misleading, however, since technology is seldom seen as an autonomous force of its own right, but more as a normative choice

of Western society in a broad sense (see Habermas, 1973). Where and how one should apply the term *technological determinism* is discussed by Bruce Bimber (1994).

Society Shapes Science and Technology

The "society shapes science and technology" perspective turns things around. Now, the determinant force is not technology but society. This approach has its origins in pressures from both business and academic discussions during the early 1970s. In business, there was a growing concern that science should be more directly connected to commercial purposes. The spill-over from basic research to business in general was perceived as poor. "Contracted research" instead of "basic research" was suggested (see the British report by Lord Rothschild on "The Organization and Management of Government R&D" in Seal, 1971; see also Elzinga, 1988).

The academic discussions emphasized social forces external to science and technology. Science and technology were to be seen in the light of the social, economic, and political interests and concerns of the wider population. There were two special lines of reasoning. One argued in strategic and political terms that science and technology should be more explicitly linked to social forces, while the other emphasized a sociological and academic approach, seeking to examine and conceptualize links between social forces and science/technology.

Thus, the OECD "Brooks Report" of 1971 (Brooks, 1971) pleaded for incorporation of "strategic choices" into science and technology—i.e., integration of the social concerns of civil groups. Furthermore, in 1972, the Office of Technology Assessment was established under the auspices of the U.S. Congress. Its main function was to identify the impact of technological application and thereby to support political deliberations concerning science and technology.

The sociological/academic line was pursued, among others, in the so-called strong program of "the sociology of scientific knowledge" (SSK) in the U.K. The idea was to study moments of alternative opportunity in science and thereby show how competing options were linked to priorities of different social forces. This type of argument was behind several valuable contributions—such as David Noble's *Forces of Production* (1984)—analyzing the develop-



ment of the numerically controlled machine tool, and the publication edited by Donald MacKenzie and Judy Wajcman, *The Social Shaping of Technology* (1985).

In some Scandinavian variants of the perspective, such as the DEMOS and the UTOPIA projects, there were attempts to convert these insights into "action research." Relevant social forces were to be mobilized and empowered, especially in newspaper typesetting, to be able to influence technical change according to their interest. The Scandinavian approach was inspired by industrial sociology. For example, Harry Braverman (1974) argued that new technology was often applied by industrialists to control work, which also lead to labor deskilling. But the Scandinavian action research projects were far more pragmatic and constructive than Braverman's analysis would suggest. DEMOS and particularly UTOPIA sought to preserve and make use of workers' skills, and to improve the quality of work during technical change in a way that was operational on both sides of the table.

The main idea of the "society shapes science and technology" approach was thus to see technology as open to external forces and negotiation. Analysts stressed that technical change is not neutral but biased by social and economic forces. Civil groups could and should be empowered and integrated into decisions concerning science and technology. In business this perspective was reflected in greater pressure for more relevance in science.

The Interactive View of the Science, Technology, and Society Relationship

The interactive perspective was presented by, among others, Wiebe Bijker (1987), Bruno Latour (1987), and Michel Callon (1986). The initial steps were taken during the 1980s, but the breakthrough for the approach came in the early 1990s under such headings as "the social construction of technology" (SCOT) and "actor-network-theory." SCOT is closely associated with SSK but shifts the focus from science to technology.

Here, technology is seen as having "interpretive flexibility," which implies that it does not develop in a linear way. Rather, technical change contains, like science in the SSK program, moments of alternative possibilities. Which steps are taken in technology depends on the specific social constituencies that are involved with the technology.

The most cited example of this approach is "the social construction of the bicycle" by Trevor Pinch and Wiebe Bijker (1984; further developed in Pinch and Bijker, 1987). The analysis goes like this: In the late nineteenth century, three competing bicycles were conceived, one made for macho men (a risky bike to ride, with a high front wheel and a low back wheel), one for women (with pedals on the same side of the bike, for example, to solve the dressing problem and meet moral standards), and a practical bicycle, mostly for elderly men. Each bicycle was, in the beginning, equally important. (All this occurred despite the fact that Leonardo da Vinci had already designed the bicycle as we know it today in the fifteenth century.) It was only when the rubber tire and improved brakes were created that the modern bicycle started to catch on. The reason was not necessarily that it was better, but, according to Pinch and Bijker, that a compromise could now be produced between the groups of elderly men (in need of a practical bike) and macho men (who could now have a challenging "fast" bike instead of a risky bike).

From this case study, Pinch and Bijker try to ground a theory comprising several concepts such as "interpretive flexibility" and "the relevant social group" (elderly men, macho men, and the like). The relevant social group is probably meant to be a more specific category than the hitherto dominant broad notions of society. They also make the argument that the relation between society and technology is not one between two distinct entities (society versus technology) but is rather a "seamless web." In addition to these constraints on technologists by the term "technological frame" (see Bijker et al., 1987). How technological frame is related to concepts of institutions more generally, or to notions of social structure, is not so clear. Bijker, however, in his latest work (Bijker, 1995), has tried to go some steps further along these lines by examining the concept of power.

The Bijker approach has had far-reaching consequences for STS. Together with other similar approaches, such as the actor-network theory of Latour and Callon, it has informed a refreshing methodological discussion in STS. Criticisms have been raised from the "science and technology shape society" perspective, most sharply by Langdon Winner (1993). Winner sees SCOT as voluntaristic, with a naive and relativist conception of reality (like "anything goes"). Another problem of the SCOT approach is its tendency to build up theory from single cases. Other relevant social science

theory and method is hardly scrutinized or applied, and statistical analysis is absent. As a consequence, the concepts developed may not seem very solid. SCOT is an intelligent and refreshing approach that has significantly improved the intellectual capability of STS, but it is not necessarily a basis for further investigations. Its long-term influence may be more indirect.

Policy, Power, and Method: The Three Perspectives Compared

A summary comparison of the three perspectives are presented in Table 3.1. As indicated, the three perspectives on science, technology, and society can be connected to competing views of policy, power, and method. In the "science and technology shape society" perspective, policy is "for" or "against" science and technology. Policy can serve to protect science and technology from external inter-

Table 3.1
Three Perspectives on STS Compared

	Science and technology shape society	Society shapes science and technology	Interactive approaches
Time	1950s-60s	1970s-80s	1990s
Definition of technology	Cause	Consequence	Cause and consequence
Independent variable	Technology	Society	Social group
Relation of actor to technology	Beneficiaries (or victims)	Negotiate interests	Seamless web
Role of policy	Protect or reject science and technology	Empower actors, create networks	Democratize
Power structure	Technological regime	Negotiations	Frames, discourses
Method	Study impact technology	Follow the artifact	Follow the actor

ence, and seek to improve institutions of science and technology.

Alternatively, policy is seen in the Luddite tradition as coming from below, from critical social groups that want to slow down the pace of technical development (the Luddites were a British workers' movement that destroyed textile machinery from 1811 to 1817 in order to slow down technical change). Power is inherent to the "technical regime," through peer-reviewed funding systems, for example. The preferred method of study is to examine the impact of science and technology on society, either the economic impact (its correlation with economic growth) or the social impact (its social context).

In the "society shapes science and technology" perspective, policy is understood as networking and strategic interaction among concerned social groups. From a practical point of view, the goal is to integrate actors, to empower them to formulate views on science and technology, and to involve them in the implementation process as well. This is intended not only from a critical point of view, in support of employees, for example, but also in policy. Most European technology policy programs in the 1980s, such as the ESPRIT program of the European Union, were established through active involvement of concerned actors in the policy process. The twelve largest electronics firms in Europe created the ESPRIT program, and these firms also received the major part of the ESPRIT funding in its early years. Hence, power is negotiated among concerned social and economic groups. The appropriate method is to follow the artifact, and from that perspective to identify relevant actors.

In the interactive perspective, one major concern is the democratization of science and technology. Science and technology are seen as social relations and thus open to discussions of all kinds. Power has to do with the social and civil discourses that surround technology in a much more radical and fundamental sense than in the strategic approach. However, any attempt to democratize these discursive processes is confronted by major practical problems. It requires the building of sophisticated and complicated new institutions that are legitimate as democratic institutions. These are problems that SCOT shares with other recent mixed approaches to democracy in political science, such as the *associative democracy* approach (Hirst, 1993), for example, putting confidence in new forms of associations among public organizations, private firms, and civil society. The interactive approach is much more precise when it comes to its primary methodological suggestion, to "follow the actor."

Phases of Technology

Superficially, at least, the three STS perspectives appear to be in conflict, as they present incongruous views on the subject matter, methodology, and the purpose and relevance of theory. The first perspective has been accused of being determinist or technocratic, the second of being radical or business-targeted, and the third of being voluntaristic or relativist. Upon closer examination, however, the three different approaches are not really incongruous at all. They simply deal with different aspects of science and technology, and may be combined if we divide specific development or technical change into different phases. By phases I mean the different stages of innovation of a technology (or piece of science), somewhat similar to the concept of the product life cycle—though with emphasis on technological rather than commercial aspects of development. For the purpose of this essay, it is useful to distinguish between three such phases:

The phase of flexibility: This phase refers primarily to the initial stages of technological innovation. Here, the final form of the technology is not yet established. As in the cases of, for example, the creation of the railroad system, radio, television, the cassette tape, the video tape, and the computer, there were a number of competing technical solutions in circulation. The initial flexible stage of technical change is normally characterized by many failing experiments and moments of alternative possibilities. Public funding may, in some cases, be needed to bear the development costs, although large companies of the capital goods sector will often be the key players and will conduct the critical experiments and cover the costs.

The phase of momentum: This term refers to the phase when a particular technology has gained strength and widespread acceptance, while others have been excluded (see, e.g., Hughes, 1969 and Staudenmaier, 1986). Because modern technical systems are complex, and incorporated into the routines and practices of many employees and firms, they will, at this stage, be linked to "vested interests" as they start to gain momentum. Once the crucial decisions have been taken, the technology cannot be changed easily or without major costs. A trajectory of "normal" problem-solving is starting to take form, along which the technology is now further developed.

The phase of diffusion: In this phase, the artifact has matured and is diffused to consumer industries and applied by final users. At this stage, a "reversed product life cycle" may, however, take off in some industries, particularly in our present age of information technology. A reversed product life cycle will move from changes of process to changes of product rather than the other way around. Thus, according to a theory proposed by Richard Barras (1986), information technology applied in services first leads to rationalization of labor (cost-saving activity), then it eventually enables development of qualitatively new production systems (using the information technology for new purposes), and finally, as a result of this, to the innovation of new products (when the final user starts to see new product characteristics). The cycle is reversed in another sense also, since some of the new products may create higher flexibility in production and consumption. Hence, a new round of flexibility evolves—valid for some employees and customers at least—leaving space for further empirical investigation.

From this analysis we may draw a number of lessons about science, technology, and society. First, science and technology are both flexible and inflexible, depending on the stage of development and the industry involved. Hence, the design of the computer was in the beginning "interpretively flexible." Eventually, however, it became more standardized, due to network externalities and economics of scale. Standardized information technology is, however, the basis for new products in services and manufacturing industries of which some are relatively flexible. Computers, understood as materializing social relations, are therefore both shaping and—still—shaped by society.

Second, science and technology have an ambiguous role in economic development. Science and technology initiatives play, as Schumpeter said of entrepreneurs, a creative/destructive role. In the case of the computer, for example, it causes unemployment and deindustrialization but also new socioeconomic opportunities. Further down the line, the technology enables new services and new flexible relationships between service workers and customers.

Third, technical change can be democratized at many stages, from the creation of a capital good to the final diffusion of it to the service sector. But the issue of democracy is very complicated because many powerful actors are at play. They often operate on a global scale and interact in networks, although not clearly within the boundaries of a national legal framework, however. Therefore,

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actors are not easily submitted to national legislation. Representative democracy, as we know it, seems to be a necessary—if unsatisfying—condition for technology and democracy.

The relationship of technology and democracy is a very complicated and important issue for the future. I offer here a brief list of some mechanisms that, in my opinion, are essential for technology and democracy at national levels and that could be examined historically:

1) Each country may create mechanisms through which users of technology can express their dissatisfaction in the early stages of technological development and diffusion. The Danish idea of consensus conferences may provide one example of this. The consensus conference is an organized discussion among lay people and experts under the auspices of the Danish parliament that leads to a consensus report. 2) Consumer movements can be stimulated to represent consumer interests at an aggregated level. 3) The population can be educated and empowered to take part in discussions of technical change at all possible levels.

Finally, services play a crucial role for applications of information and communication technology. This is an issue that until now has been underresearched. Because services often take the form of relations rather than products, the diffusion of technology to services and innovation in services becomes a focal point for studying the impact of technology on human interaction.

Concluding Remarks: Opening the Doors of STS

In this essay I have suggested that science, technology, and society (STS) consists of several seemingly competing, if not conflicting, perspectives, because they relate to different notions of power, policy, and method. Nevertheless, the perspectives can be combined. Combining the perspectives does not mean, however, that we create a unitary approach of STS. What I intend is rather a pluralistic and open approach. To open the doors among the different perspectives is a major challenge for STS, which may also require a thorough deliberation of the different related policy interests. It may be more comfortable to remain within one of the perspectives, but to move across their thresholds can lead to more fruitful scholarly interaction and a stronger role for STS, which, without such movement, may run the risk of being pulled apart by the competing policy interests.

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