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THE DUALITY OF TECHNOLOGY: RETHINKING THE CONCEPT OF TECHNOLOGY IN ORGANIZATIONS*

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This paper develops a new theoretical model with which to examine the interaction between technology and organizations. Early research studies assumed technology to be an objective, external force that would have deterministic impacts on organizational properties such as structure. Later researchers focused on the human aspect of technology, seeing it as the outcome of strategic choice and social action. This paper suggests that either view is incomplete, and proposes a reconceptualization of technology that takes both perspectives into account. A theoretical model—the structurational model of technology—is built on the basis of this new conceptualization, and its workings explored through discussion of a field study of information technology. The paper suggests that the reformulation of the technology concept and the structurational model of technology allow a deeper and more dialectical understanding of the interaction between technology and organizations. This understanding provides insight into the limits and opportunities of human choice, technology development and use, and organizational design. Implications for future research of the new concept of technology and the structurational model of technology are discussed.

(ORGANIZATIONS; STRUCTURATION THEORY; STRUCTURATIONAL MODEL OF TECHNOLOGY; TECHNOLOGY)

Technology has always been a central variable in organizational theory, informing research and practice. Despite years of investigative effort there is little agreement on the definition and measurement of technology, and no compelling evidence on the precise role of technology in organizational affairs. I will argue that the divergent definitions and opposing perspectives associated with technological research have limited our understanding of how technology interacts with organizations, and that these incompatibilities cannot be resolved by mutual concession. What is needed is a reconstruction of the concept of technology, which fundamentally re-examines our current notions of technology and its role in organizations.

In this paper, I undertake such a reconstruction and present a view of technology that draws on Giddens' (1976, 1979, 1984) theory of structuration. My re-examination leads to a model for analyzing the nature and role of technology in organizations, which I term the structurational model of technology. Before proceeding to the premises and components of this model, prior views of technology are reviewed to serve as background and motivation for the alternative proposed here.

Rethinking Prior Conceptualizations of Technology

Prior conceptualizations of technology have each focused selectively on some aspects of technology, at the expense of others, with the result that the current state of knowledge about technology in organizations is ambiguous and conflicting (Atwell and Rule 1984; Barley 1990; Davis and Taylor 1986; Hartmann et al. 1986; Scott 1981). Two important aspects of the technology concept are *scope*—what is defined as comprising technology, and *role*—how is the interaction between technology and organizations defined. Both these aspects inform prior technological research, where they have been specified and used discrepantly.

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Differences in Scope

Two views on the scope of technology have pervaded (and shaped) studies of technology, reflecting the different claims to generalizability that researchers have intended with their work. The one set of studies has focused on technology as “hardware,” that is, the equipment, machines, and instruments that humans use in productive activities, whether industrial or informational devices (Barley 1986; Blau et al. 1976; Bjørn-Andersen, Eason and Robey 1986; Davis 1989; Hickson et al. 1969; Lucas 1975; Noble 1984; Robey 1981; Shaiken 1985; Woodward 1958; Zuboff 1988). The range of hardware across industries and organizations, however, has led to multiple, context-specific definitions of technology, which have inhibited comparisons across studies and settings. For example, Woodward’s (1958) categorization of technology as industrial production techniques is limited to manufacturing firms. Alternatively, this approach has also resulted in the use of broad definitions of technology which, having to accommodate a wide range of machinery, become so abstract as to have limited discriminatory or informational value. For example, Blau et al.’s (1976) definition of technology, deployed in the factory and the office, is given as “the substitution of equipment for human labor” (1976, p. 21).

In the “hardware” view, technology is a meaningful variable only in those organizations that employ machinery in their productive activities. This restriction prompted researchers to try and generalize the scope of the technology variable so as to encompass organizations such as service firms and educational institutions. The technology concept was thus extended to “social technologies,” thereby including the generic tasks, techniques, and knowledge utilized when humans engage in any productive activities (Eveland 1986; Perrow 1967; Thompson 1967). For example, Perrow (1967) sees organizations as places where raw materials are transformed, thus defining what is done to raw materials and how it is done, as the technology of organizations, while Thompson (1967) characterizes the work flow of different organizations in terms of long-linked, mediating, and intensive technologies.

While useful, in that it allows technology to be a meaningful variable in all organizations, and it recognizes that there is more to technology than just the hardware, this generic approach to technology creates boundary and measurement ambiguity (Mintzberg 1979, p. 250). It also overlooks valuable information about the mediation of human action by machines. That is, even as we gain in generality, we have lost the ability to ask questions about how artifacts interact with human agents. By aggregating task, technique, knowledge, and tools into a single construct—technology—interaction among these constituting components and with humans is ignored. For example, we cannot examine how different assumptions, knowledge, and techniques can be embedded in different kinds of artifacts or practices, and how these will have differential consequences for human action and cognition. Nor can we examine how the rules and procedures structured into a machine are differentially appropriated, changed, or ignored by the agents executing work (Perrow 1983; Suchman and Wynn 1984; Wynne 1988).

Differences in Role

Three streams of technology research can be distinguished by their definitions of the role played by technology in organizations, reflecting the philosophical opposition between subjective and objective realms that has dominated the social sciences (Bernstein 1978; Burrell and Morgan 1979; Giddens 1979). The early work assumed technology to be an objective, external force that would have (relatively) deterministic impacts on organizational properties such as structure. In contrast, a later group of researchers focused on the human action aspect of technology, seeing it more as a

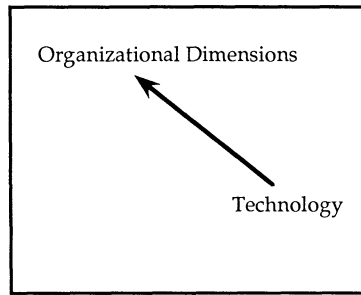


FIGURE 1. Technological Imperative Model.

product of shared interpretations or interventions. The third, and more recent, work on technology has reverted to a “soft” determinism where technology is posited as an external force having impacts, but where these impacts are moderated by human actors and organizational contexts.

The “Technological Imperative” Model. In this body of work, studies of technology (Aldrich 1972; Blau et al. 1976; Hickson et al. 1969; Perrow 1967; Shepard 1977; Woodward 1958] and information technology (Carter 1984; Davis 1989; Foster and Flynn 1984; Hiltz and Johnson 1990; Leavitt and Whistler 1958; Pfeffer and Leblebici 1977; Siegel et al. 1986) examine the impacts of technology on organizational dimensions such as structure, size, performance, and centralization/decentralization, as well as individual level dimensions such as job satisfaction, task complexity, skill levels, communication effectiveness, and productivity. The premise is that the technology as well as the organizational and individual variables can be measured and predicted (see Figure 1).

Such research treats technology as an independent influence on human behavior or organizational properties, that exerts unidirectional, causal influences over humans and organizations, similar to those operating in nature (Giddens 1984, p. 207). Some of this research allows for the influence of technology to be moderated by contextual variables, proposing a contingency model of technology’s effects (e.g. Jarvenpaa 1989; Lucas 1975). While providing insight into the often determining aspects of technology, this body of research largely ignores the action of humans in developing, appropriating, and changing technology. As a consequence, this perspective furnishes an incomplete account of technology and its interaction with organizations.

The “Strategic Choice” Model. This perspective suggests that technology is not an external object, but a product of ongoing human action, design, and appropriation. Three research foci within this perspective are discernable. One stream focuses on how a particular technology is physically constructed through the social interactions and political choices of human actors. Technology is here understood to be a dependent variable, contingent on other forces in the organization, most notably powerful human actors (see Figure 2). This perspective does not accept that technology is given or immutable, focusing attention instead on the manner in which technology is influenced by the context and strategies of technology decision makers and users (Child 1972; Davis and Taylor 1986; Kling and Iacono 1984; Markus 1983; Perrow 1983; Trist et al. 1963; Zuboff 1988).

Particularly relevant here are socio-technical studies, which are premised on the belief that outcomes such as job satisfaction and productivity of workers can be manipulated by jointly “optimizing” the social and technical factors of jobs (Davis and Taylor 1986; Trist et al. 1963). A similar premise runs through the socio-technical research in information technology (Bostrom and Heinen 1977; Mumford 1981) and

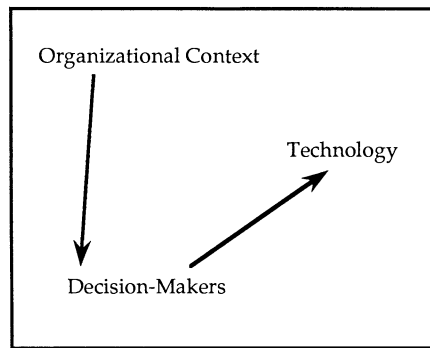


FIGURE 2. Strategic Choice Model.

the work of Zuboff (1988), which calls for a re-examination and restructuring of organizations around the potential of information technology. Zuboff suggests that because information technology can be designed with different intentions (to “automate” or “informatize” work), it will have different implications for workers (controlling and deskilling or empowering and upskilling, respectively).

These analyses, however, rely too heavily on the capability of human agents. The presumption is made that once technology is designed to embody the “appropriate” (optimizing or informing) objectives and once managers are committed to this “appropriate” strategy, more rewarding workplaces, more fluid organizations, a new division of labor, and better performance will result. But, as many of the case studies in Zuboff (1988) reveal, how a technology is deployed and appropriated depends on social and economic forces beyond managerial intent (Powell 1987; Sabel 1982; Shaiken 1985), which may thwart any intended reconstruction of jobs and technology. Some of these forces include institutional properties of the organization, micropolitics of the workplace, features of the environment, and unintended consequences of organizational change. Such forces may account for the mixed success that socio-technical interventions have had in a range of organizations (Kelly 1978; Pasmore et al. 1982).

The second stream examines how shared interpretations around a certain technology arise and affect the development of and interaction with that technology. Empirical studies adopting this social constructionist view of technology have been done by sociologists of technology (Bijker 1987; Bijker, Hughes and Pinch 1987; Collins 1987; Pinch and Bijker 1984, 1987; Woolgar 1985; Wynne 1988), and information technology researchers (Boland and Day 1982; Hirschheim, Klein and Newman 1987; Klein and Hirschheim 1983; Newman and Rosenberg 1985). While usefully demonstrating how meanings around a technology arise and are sustained, this body of research tends to downplay the material and structural aspects of interaction with technology.

The final research stream in this tradition is represented by Marxist accounts of technology such as those of Braverman (1974), Cooley (1980), Edwards (1979), Noble (1984), and Perrolle (1986). While carefully outlining the manner in which technology is devised and deployed to further the political and economic interests of powerful actors (the social construction of technology at the point of initiation), these studies do not adequately deal with human agency in the workplace (the social construction of technology at the point of use). They consequently fail to account for the diverse ways in which a technology is appropriated and utilized by workers, and the nonuniform manner in which it structures individual and organizational action (Burawoy 1979; Powell 1987). The limitation here is the selectivity with which the notion of

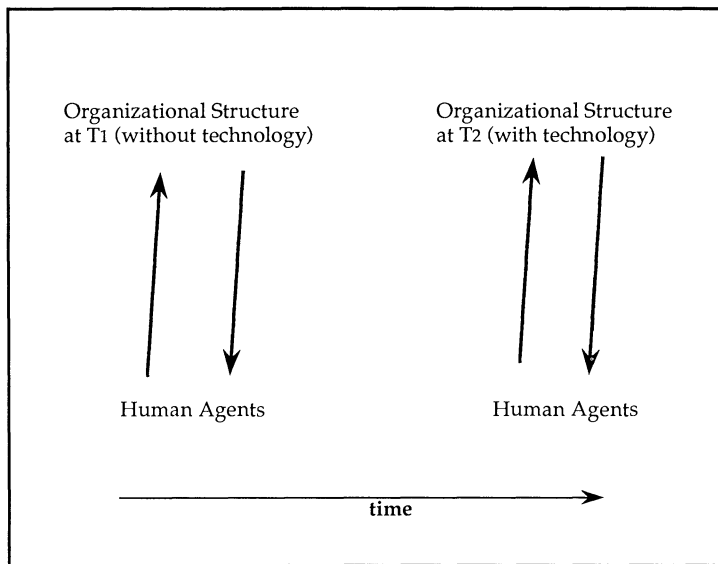


FIGURE 3. Barley's (1986) Model of Technology-Triggered Structural Change.

human agency is applied, where only managers or technology designers have the authority and means to shape the technology. Human agents such as workers using the technology are portrayed as relatively powerless, and their actions and cognitions as determined by the technology. Yet, worker action may well change how technology is interpreted and operated, and hence the implications for organizations (Burawoy 1985; Jönsson and Grönlund 1988; Perrow 1983; Wynne 1988). As Mohrman and Lawler (1984, p. 136) point out: "Because technologies are socially constructed, they can be reconstructed as well. . . . The technology itself can be changed by those using it."

Model of Technology as Trigger of Structural Change. A third perspective on the relationship between technology and structure is provided by Barley (1986, 1990), and involves portraying technology as an intervention into the relationship between human agents and organizational structure, which potentially changes it (see Figure 3). Barley (1986) employed a longitudinal field study to examine the introduction of similar radiographic technology into different organizations. Within each organization, he found that the technology triggered a change in departmental structure by altering institutionalized roles and patterns of interaction. By comparing two organizations and determining that they responded differently to the implementation of a similar technology, Barley (1986, p. 107) effectively demonstrated that: "Technologies do influence organizational structures in orderly ways, but their influence depends on the specific historical process in which they are embedded."

Within his frame of reference Barley posits a role for technology, not as material cause, but as a material trigger, occasioning certain social dynamics that lead to anticipated and unanticipated structuring consequences (such as increased decentralization in his study). Technology is understood as a social object whose meaning is defined by the context of use, while its physical form and function remain fixed across time and contexts of use. While Barley asserts that some features of the technology are socially constructed, he does not allow for the physical modification of technology during use. Given a technology such as CT scanners—with relatively fixed and standardized functions and features—such a view may be appropriate. It is, however, not generally appropriate, and is particularly inadequate in the case of information

technologies. While technologies may appear to have objective forms and functions at one point, these can and do vary by different users, by different contexts of use, and by the same users over time.

Reviewing the Technology Literature

The above discussion has been a brief and somewhat critical examination of extant research into the scope and role of technology in organizations. This examination is not original, as recent discussions in the organizational literature have similarly critiqued this work (Attewell and Rule 1984; Davis and Taylor 1986; Hodson and Parker 1988; Markus and Robey 1988; Perrow 1983; Powell 1987; Sabel 1982). However, while researchers have concentrated on deconstruction to identify the limitations imposed by overly deterministic or unduly voluntaristic perspectives, they have not engaged in the equally important task of reconstruction. What is still lacking is a new conceptualization of technology and its relationship with organizations that will allow us to move beyond critique to an alternative conceptual basis from which to conduct future research.

In this paper, I employ the tenets of structuration theory to reconstruct the concept of technology and to propose a model for investigating the relationship between technology and organizations. In defining my concept of technology, I restrict its *scope* to material artifacts (various configurations of hardware and software). I wish to sustain a distinction—at least theoretically—between the material nature of technology and the human activities that design or use those artifacts. This definition is consistent with the view that overloading the technology concept is unnecessarily limiting, but it should not be understood as an exclusive focus on technology as a physical object. In contrast, the analytic decoupling of artifacts from human action allows me to conceptualize material artifacts as the outcome of coordinated human action and hence as inherently social. It also facilitates my framing of the *role* of technology in terms of a mutual interaction between human agents and technology, and hence as both structural and socially constructed.

My proposal for a structural model of technology makes no claims as to completeness or perfection, and is presented as another in the stream of thinking about the technology phenomenon. It too, inevitably, is limited by its author's beliefs and interests. I submit however, that the reconceptualization, while bounded, overcomes certain dualisms and abstractions that have inhered in prior perspectives, and sensitizes us to the dialectical interplay of technology and organizations.

A Structural Model of Technology

Recent work in social theory (Giddens 1976, 1984) and philosophy of science (Bernstein 1978; Bhaskar 1979) has challenged the long-standing opposition in the social sciences between subjective and objective dimensions of social reality, and proposes an alternative meta-theory which incorporates both dimensions. Giddens' theory of structuration (1979, 1984) is one such alternative, and a number of organizational researchers have adopted and used the theory in their analyses of organizational processes (Barley 1986; Manning 1982; Pettigrew 1985; Ranson, Hinings and Greenwood 1980; Riley 1983; Roberts and Scapens 1985; Smith 1983; Spybey 1984; Willmott 1987). For these researchers, structuration offers a solution to the dilemma of choosing between subjective and objective conceptions of organizations, and allows them to embrace both (Dow 1988; Poole and Van de Ven 1989; Willmott 1981).

The Theory of Structuration

Structuration is posited as a social process that involves the reciprocal interaction of human actors and structural features of organizations. The theory of structuration recognizes that human actions are enabled and constrained by structures, yet that these structures are the result of previous actions. In Giddens' framework, structure is understood paradigmatically, that is, as a generic concept that is only manifested in the structural properties of social systems (Giddens 1979, pp. 64–65). Structural properties consist of the rules and resources that human agents use in their everyday interaction. These rules and resources mediate human action, while at the same time they are reaffirmed through being used by human actors.

In this theory, the role of human actors in reaffirming structural properties is highlighted so as to avoid reification. The recognition that actors are knowledgeable and reflexive is a central premise. Giddens notes (1984, p. 22): "All social actors, all human beings are highly 'learned' in respect of knowledge which they possess and apply, in the production and reproduction of day-to-day social encounters." Giddens distinguishes between discursive and practical knowledge, where the former refers to knowledge the actors are able to articulate (what is said), and the latter refers to tacit knowledge, which actors are able to draw on in action but are unable to express (what is simply done). Reflexivity refers to the capacity of humans to routinely observe and understand what they are doing while they are doing it. It is not merely self-consciousness, but includes the continuous monitoring of physical and social contexts, and activities (their own and others) (Giddens 1984, p. 5). Actors' knowledge and reflexivity, however, is always bounded to some extent by the situated nature of action, the difficulty of articulating tacit knowledge, unconscious sources of motivation, and unintended consequences of action (Giddens 1979, p. 144).

Through the regular action of knowledgeable and reflexive actors, patterns of interactions become established as standardized practices in organizations, e.g., ways of manufacturing a product, coordinating a meeting, or evaluating an employee. Over time, habitual use of such practices eventually becomes institutionalized, forming the structural properties of organizations. These structural or institutionalized properties (structure) are drawn on by humans in their ongoing interactions (agency), even as such use, in turn, reinforces the institutionalized properties. In this formulation—known as the *duality of structure*—Giddens overcomes the dualism between objective, structural features of organizations and subjective, knowledgeable action of human agents.

When humans act in organizations, they create and recreate three fundamental elements of social interaction (Giddens 1976, p. 104): meaning, power, and norms. While these elements are highly interdependent and not separable in practice, for analytical purposes we can treat them as distinct, examining each from the perspective of human agency and institutionalized properties.

—From an agency point of view, human interaction involves the constitution and communication of *meaning*. This is achieved via interpretive schemes or stocks of knowledge that humans draw on in their ongoing interaction with the world, which "... form the core of mutual knowledge whereby an accountable universe of meaning is sustained through and in processes of interaction" (Giddens 1979, p. 83). The interpretive schemes, however, do more than merely enable shared meanings and hence mediate communication. From the perspective of institutionalized properties, interpretive schemes represent organizational *structures of signification*, which represent the organizational rules that inform and define interaction. Interpretive schemes are also reinforced or changed through social interaction, as the organizational rules are reaffirmed or challenged through their use by human agents. Thus, in

any interaction, shared knowledge is not merely part of the background, but is an integral part of the social encounter, in part organizing it, and in part being shaped by the interaction itself.

—From an agency perspective, *power* enters into human interaction through providing organizational capabilities for humans to accomplish outcomes. Power is here understood as “transformative capacity,” the power of human action to transform the social and material world (Roberts and Scapens 1985, p. 449). Its use in organizations is mediated via the organizational resources that participants bring to, and mobilize within, interaction (Giddens 1979, pp. 92–93). Two kinds of resources are recognized, authoritative (extending over persons) and allocative (extending over objects or material phenomena). While these facilities are the means through which power is exercised, from the perspective of institutional properties they constitute organizational *structures of domination*, which reflect the fact that all social systems are marked by an asymmetry of authoritative and allocative resources. However, there always remains the potential for agents to act to change a particular structure of domination, a potentiality referred to as the *dialectic of control* by Giddens (1984, p. 16): “. . . all forms of dependence offer some resources whereby those who are subordinate can influence the activities of their superiors.” When a given asymmetry of resources is drawn on by human actors in interaction, the existing structure of domination is reaffirmed. It is only when the existing asymmetry of resources is changed—either through being explicitly altered or through being gradually and imperceptibly shifted—that the existing structure of domination may be modified or undermined.

—From an agency perspective, norms are organizational conventions or rules governing legitimate or “appropriate” conduct. Interaction in organizations does not occur blindly but is guided by the application of *normative sanctions*, expressed through the cultural norms prevailing in an organization. From the perspective of institutional properties, however, norms constitute organizational *structures of legitimation*, whereby a moral order within an organization is articulated and sustained through rituals, socialization practices, and tradition.

Giddens does not explicitly address the issue of technology in his structuration paradigm, and while structuration theory has been employed to study technology-induced organizational change (Barley 1986), and applied to the use of group decision support systems (Poole and DeSanctis 1989, 1990) and computer conferencing systems (Robey, Vaverek and Saunders 1989), no attempt has been made to use structuration theory to reconceptualize the notion of technology, and to reformulate the relationship between technology and organizations. In suggesting that we try and understand technology from the point of view of structuration, I propose that it be considered as one kind of structural property of organizations developing and/or using technology. That is, technology embodies and hence is an instantiation of some of the rules and resources constituting the structure of an organization. The details of a structural model of technology are explicated in the following section, and the model is then illustrated by drawing on empirical work.

Premises of a Structural Model of Technology

Technology is created and changed by human action, yet it is also used by humans to accomplish some action. This recursive notion of technology—which I call the *duality of technology*—is the first of the premises I elaborate below. The second, a corollary of the first, is that technology is *interpretively flexible*, hence that the interaction of technology and organizations is a function of the different actors and socio-historical contexts implicated in its development and use.

(i) *The Duality of Technology*. The duality of technology identifies prior views of technology—as either objective force or as socially constructed product—as a false dichotomy. Technology is the product of human action, while it also assumes structural properties. That is, technology is physically constructed by actors working in a given social context, and technology is socially constructed by actors through the different meanings they attach to it and the various features they emphasize and use. However, it is also the case that once developed and deployed, technology tends to become reified and institutionalized, losing its connection with the human agents that constructed it or gave it meaning, and it appears to be part of the objective, structural properties of the organization.

Agency and structure are not independent. It is the ongoing action of human agents in habitually drawing on a technology that objectifies and institutionalizes it. Thus, if agents changed the technology—physically or interpretively—every time they used it, it would not assume the stability and taken-for-grantedness that is necessary for institutionalization. But such a constantly evolving interaction with technology would undermine many of the advantages that accrue from using technology to accomplish work. We do not need to physically or socially reconstruct the telephone, elevator, or typewriter every time we use it. However, there clearly are occasions where continued unreflective use of a technology is inappropriate or ineffective.

Wynne (1988, p. 159), for example, describes the case of a British water-transfer tunnel designed in the seventies to serve the huge increase in water demand expected as a result of the projected industrial and residential growth of Lancashire. At the time of the design and implementation of the technology, it was assumed that the scheme would pump continually and at full capacity. However, a decade later it turned out that these social assumptions had been incorrect; Lancashire was economically depressed and water demand had not increased. As a result, the scheme was only used intermittently and lay stagnant for periods of several weeks. Such operation of the scheme allowed the formation of a large void in the tunnel, which eventually caused a major methane explosion in the tunnel with significant loss of life. The operation of the technology depended in this case on the once-relevant, but now-obsolete and forgotten assumptions about the socio-economic growth of the area. Having been designed and built into the technology, these assumptions served as conditions for the “normal” operation of the technology. That the conditions were no longer applicable to current operational circumstances was no longer known to users, and unavailable for reflection by them or the technology sponsors and developers who were long gone.

As was indicated above, a crucial aspect of human action is that it is knowledgeable and reflexive. Agency refers to capability not intentionality, although action taken by humans may have intended and unintended consequences. For example, a company’s adoption of electronic mail may have the intended consequence of increasing communication and information sharing, and the unintended consequence of reducing status barriers and social context cues (Sproull and Kiesler 1986). Further, while personal action of human agents using technology has a direct effect (intended and unintended) on local conditions, it also has an indirect effect (often unintended) on the institutional environment in which the agents are situated. For example, a person may use a spreadsheet program to compute an organization’s annual revenues, or to create the impression of a legitimate business, but the effect of that action is to reaffirm the relevance and primacy of the “rules of accountability” established by the accounting profession. Even where actions are directly intended to preserve or change some aspect of the institutional environment, the result is not guaranteed. For example, managers may implement automated production procedures to reposition their organization competitively. The result may be that since the organization’s

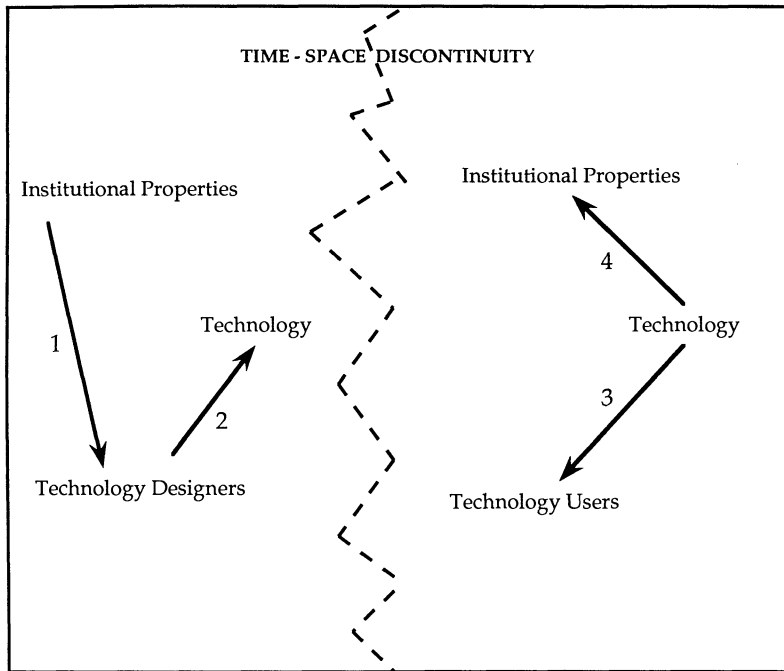


FIGURE 4. Traditional Models of Technology Design and Technology Use (Discontinuous in Time-Space).

operations are now much more dependent on the technology, they are also more vulnerable to technological breakdowns which disrupt workflow, increase costs and delays, and adversely affect customers.

(ii) *The Interpretive Flexibility of Technology.* As we saw above, the duality of technology has tended to be suppressed in organizational discourse in favor of a dualism which emphasizes only one view of technology. To some extent this myopia is fostered by the fact that one aspect of the duality is often invisible in organizations. With many types of technology the processes of development and use are often accomplished in different organizations. That is, many of the actions that *constitute* the technology are often separated in time and space from the actions that are *constituted by* the technology, with the former typically occurring in vendor organizations, and the latter occurring in customer sites. In these circumstances, it is not surprising that users of a technology often treat it as a closed system or “black box,” while designers tend to adopt an open systems perspective on technology.

This time-space discontinuity is related to the notions of temporal scope that were examined above. The dualistic view of technology as fixed object or as product of human action is influenced by the different temporal stages of technology that investigators have chosen to focus on. Recognizing the time-space discontinuity between the design and use of technology gives us insight into how it has promoted the conceptual dualism dominating the literature (see Figure 4). Researchers examining the design and development of a technology (the left-hand side of Figure 4) are confronted with the essentially constructed nature of the technology. They examine how technology designers, influenced by the institutional properties of their organization (arrow 1), fashion and construct a technology to meet managerial goals (arrow 2). Such studies are less likely to treat technology as fixed or objective, recognizing its dynamic and contingent features (as in the strategic choice studies). Researchers examining the utilization of a technology in an office or factory, on the other hand (the right-hand side of Figure 4), focus on how users of technology are influenced by

the given technology (arrow 3), and how the technology affects institutional properties of the organization (arrow 4). Such researchers are less inclined to focus on the human agency that initially produced the technology, and tend not to recognize the ongoing social and physical construction of technology that occurs during its use.

Rather than positing design and use as disconnected moments or stages in a technology's lifecycle, the structurational model of technology posits artifacts as potentially modifiable throughout their existence. In attempting to understand technology as continually socially and physically constructed, it is useful to discriminate analytically between human action which affects technology and that which is affected by technology. I suggest that we recognize human interaction with technology as having two iterative modes: the *design mode* and the *use mode*. I emphasize that this distinction is an analytical convenience only, and that in reality these modes of interaction are tightly coupled.

Even as we recognize that technologies are designed and used recursively, we also need to acknowledge the differences among technologies in the degree to which users can effect redesign. While we can expect a greater engagement of human agents during the initial development of a technology, this does not discount the ongoing potential for users to change it (physically and socially) throughout their interaction with it. In using a technology, users interpret, appropriate, and manipulate it in various ways, being influenced by a number of individual and social factors. Despite these opportunities for engagement with technology, however, rigid and routinized views of, and interactions with, technology do develop. Such developments are a function of the interaction between technology and organizations and are not inherent in the nature of technology.

For example, many technologies such as manufacturing and medical technologies have assumed such a rigidity at their point of deployment—the factory floor or the hospital—that they appear to be fixed means of production. But even the most “black box” technology has to be apprehended and activated by human agency to be effectual, and in such interaction users shape technology and its effects. For example, Jönsson and Grönlund (1988) describe how machine operators participate in its testing and adaptation, while Wynne (1988) cites instances where operators of a range of technological systems—from airplanes to chemical plants—routinely deviate from formal, rule-bound operating practices to deal with complex interdependencies, unanticipated events, and the contingencies of local conditions. The Challenger shuttle disaster is a case in point. The inquiry revealed that the space shuttle had often been operated with various malfunctioning components, and because O-ring damage and leakage had been experienced frequently during the shuttle flight history, “. . . the experts had come to accept it as a new normality” (Wynne 1988, p. 151). Wynne notes about this and the other technological cases: “The whole system can be seen to have been evolving uncertainly according to innumerable *ad hoc* judgements and assumptions. These created a new set of more private informal ‘rules’ beneath the discourse of formal rules and check procedures” [ibid.].

Examples of sabotage and avoidance of use in more rigid technologies such as assembly lines, chemical plants, and power stations further illustrate the role of users shaping technology and its effects (Perrow 1983; Shaiken 1985; Wynne 1988), while studies of offices reveal similar patterns of users influencing technology through informal practices, avoidance behavior, or “working to rule” (Garson 1988; Howard 1985; Markus 1983; Zuboff 1988). Mackay (1988), for example, describes how users of an electronic mail system employed different strategies for using it based on their different task contingencies and individual preferences. As a result, the technology was appropriated in diverse ways and came to have different meanings and effects for different users.

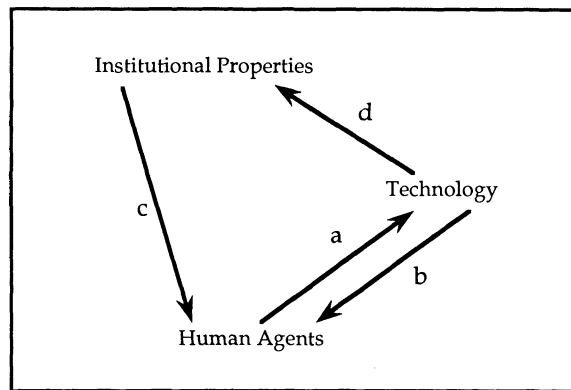
What is critical in discriminating between more or less rigid technologies is the capacity of users to control their interaction with the technology and its characteristics. Because users can potentially exercise such control at any time during a technology's existence, the apparent disjuncture between the design and use stages is artificial and misleading. I will use the term *interpretive flexibility*, following Pinch and Bijker (1984, 1987), to refer to the degree to which users of a technology are engaged in its constitution (physically and/or socially) during development or use. Interpretive flexibility is an attribute of the relationship between humans and technology and hence it is influenced by characteristics of the material artifact (e.g., the specific hardware and software comprising the technology), characteristics of the human agents (e.g., experience, motivation), and characteristics of the context (e.g., social relations, task assignment, resource allocations).

While the notion of interpretive flexibility recognizes that there is flexibility in the design, use, and interpretation of technology, the factors influencing it allow us to acknowledge that the interpretive flexibility of any given technology is not infinite. On the one hand, it is constrained by the material characteristics of that technology. Technology is at some level physical in nature and hence bounded by the state of the art in materials, energy, and so on. On the other hand, it is constrained by the institutional contexts (structures of signification, legitimation and domination) and different levels of knowledge and power affecting actors during the technology's design and use. For example, the initial designers of a technology have tended to align with managerial objectives (Markus and Bjørn-Andersen 1987; Noble 1984; Sterling 1984), with the result that many technologies reinforce the institutional status quo, emphasizing standardization, control, and efficiency. However, there is nothing inevitable about this alliance, and it may shift as the traditional division of labor between designers and users blurs with the increased deployment of computer-based artifacts (Hirschhorn 1984; Shaiken 1985), and as users of technology grow in number, influence, and knowledge. It may also be influenced by changing economic conditions which may pressure managers to alter strategies, organizational forms, and operating norms.

Components of the Structural Model of Technology

The structural model of technology comprises the following components: (i) human agents—technology designers, users, and decision-makers, (ii) technology—material artifacts mediating task execution in the workplace; and (iii) institutional properties of organizations, including organizational dimensions such as structural arrangements, business strategies, ideology, culture, control mechanisms, standard operating procedures, division of labor, expertise, communication patterns, as well as environmental pressures such as government regulation, competitive forces, vendor strategies, professional norms, state of knowledge about technology, and socio-economic conditions. The following discussion of the structural model of technology makes reference to the relationships depicted in Figure 5.

I. *Technology is the product of human action (arrow a).* As a human artifact, technology only comes into existence through creative human action, and is sustained by human action through the ongoing maintenance and adaptation of technology (automobiles need servicing, typewriters require new ribbons, and even pencils need sharpening). Further, human action constitutes technology through using it. That is, once created, technology is deployed in organizations but remains inanimate and hence ineffectual unless it is given meaning and is manipulated—directly or indirectly—by humans. On its own, technology is of no import; it plays no meaningful role in human affairs. It is only through the appropriation of technology by humans (whether



ARROW	TYPE OF INFLUENCE	NATURE OF INFLUENCE
a	Technology as a Product of Human Action	Technology is an outcome of such human action as design, development, appropriation, and modification
b	Technology as a Medium of Human Action	Technology facilitates and constrains human action through the provision of interpretive schemes, facilities, and norms
c	Institutional Conditions of Interaction with Technology	Institutional Properties influence humans in their interaction with technology, for example, intentions, professional norms, state of the art in materials and knowledge, design standards, and available resources (time, money, skills)
d	Institutional Consequences of Interaction with Technology	Interaction with technology influences the institutional properties of an organization, through reinforcing or transforming structures of signification, domination, and legitimation

FIGURE 5. Structurational Model of Technology.

for productive or symbolic ends) that it plays a significant role and hence exerts influence. It is only through human action that technology *qua* technology can be understood.

The interpretive flexibility of technology operates in two modes of interaction. In the *design mode*, human agents build into technology certain interpretive schemes (rules reflecting knowledge of the work being automated), certain facilities (resources to accomplish that work), and certain norms (rules that define the organizationally sanctioned way of executing that work). In the *use mode*, human agents appropriate technology by assigning shared meanings to it, which influence their appropriation of the interpretive schemes, facilities, and norms designed into the technology, thus allowing those elements to influence their task execution. In many organizations, individuals may have little control over when or how to use technology, and hence little discretion over which meanings and elements influence their interaction with it. But these constraints are institutional, and are not inherent in the technological artifact itself. Users can always choose (at the risk of censure) not to utilize a technology, or choose to modify their engagement with it. The notion that technology needs to be appropriated by humans retains the element of control that users always have (however slight) in interacting with technology.

II. *Technology is the medium of human action (arrow b)*. Because technology is used by workers, it mediates their activities. Anyone who has used a typewriter,

telephone, computer, hammer, or pencil can attest that technology facilitates the performance of certain kinds of work. That the technology also constrains the performance by facilitating it in a particular manner is an important corollary of this. This influence resembles that posited by earlier examinations of the “impacts of technology” on the use of technology. However, there are two significant differences in the structurational model. One is the recognition that technology cannot determine social practices. Human agency is always needed to use technology and this implies the possibility of “choosing to act otherwise.” Thus, technology can only condition social practices. The other difference is the acknowledgement that technology, in conditioning social practices, is both facilitating and constraining. Technology does not only constrain or only enable, but rather does both. This dual influence has typically not been recognized in studies that attempt to determine definitively whether technology has “positive” or “negative” effects (Attewell and Rule 1984; Hartmann et al. 1986). Giddens’ (1984) framework allows us to recognize that technology—as a medium of social practices—necessarily has both restricting and enabling implications. Which implication dominates depends on multiple factors including the actions and motives of designers and implementors, the institutional context in which technology is embedded, and the autonomy and capability of particular users.

Other influences that reflect the interaction between human agents and structural properties are also relevant to a study of technology use in organizations. However, to punctuate the key aspects of technology, only those influences directly involving technology are discussed here. Two such influences are particularly important in the structurational model of technology.

III. One influence concerns the nature of human action in organizations, which is situated action, and hence shaped by organizational contexts (*arrow c*). When acting on technology (whether designing, appropriating, modifying, or even resisting it), human agents are influenced by the institutional properties of their setting. They draw on existing stocks of knowledge, resources, and norms to perform their work. Often these influences are unarticulated, or reflected on only fleetingly by human agents (Giddens 1984), and are here referred to as the *institutional conditions of interaction with technology*. Anderson (1988) compared the development of numerically controlled (NC) equipment in two different contexts, the U.S. and Norway, and found that different institutional settings, funding, labor relations, socio-economic conditions, and cultural traditions shaped very different kinds of NC technologies. The case of the British water-transfer tunnel (Wynne 1988) described above tragically reveals how particular institutional conditions influenced the design and development of a specific technology, while Barley’s (1986, 1990) examination of how two different hospitals used similar medical scanning technology shows how different institutional conditions influenced the way people interacted with technology. Technology is built and used within certain social and historical circumstances and its form and functioning will bear the imprint of those conditions.

IV. The final influence involves the manner in which human action when it uses technology acts upon the institutional properties of an organization (*arrow d*), either by reinforcing them (more typically) or by transforming them (less frequently). Technology is an “enacted environment” (Weick 1979, p. 260) whose construction and use is conditioned by an organization’s structures of signification, domination, and legitimation. The appropriation and use of technology implies the change or reinforcement of these three institutional structures. These effects—comprising the *institutional consequences of interaction with technology*—are often not reflected on by users, who are generally unaware of their role in either reaffirming or disrupting an institutional status quo. When users conform to the technology’s embedded rules and

resources, they unwittingly sustain the institutional structures in which the technology is deployed.

When users do not use the technology as it was intended, they may undermine and sometimes transform the embedded rules and resources, and hence the institutional context and strategic objectives of the technology's creators, sponsors, and implementors. This may happen more frequently than one would imagine. Perrow (1983) and Wynne (1988) show how users operating complex technologies often have to deal with high levels of stress, ambiguity, and unstructured local situations that deviate from "normal" operating conditions. In these situations, the negotiated or enacted use of technology is often very different to the prescribed, mechanical operation of the technology. Wynne notes (1988, p. 152): "Thus implementing design commitments and operating technological systems involves the continual invention and negotiation of new rules and relationships, not merely the enactment of designed ones. This develops the technology in unanticipated ways as it is 'normalized'." Tyre's (1988) study of process technology includes the case of a new grinding machine being introduced into an automated manufacturing plant. Initial integration problems forced project engineers to install a temporary manual "workaround." Although the manual workaround was inefficient, operators quickly learned to depend on it to accomplish their work. Later, when the grinder was fully functional, operators prevented the engineers from dismantling the "temporary" workaround. The new technology with its workaround has become so integrated into operators' routines that it became the "normal" or institutionalized mode of operating the grinding machine.

In the model of technology proposed here, structuration is understood as a dynamic process which is embedded historically and contextually. While the main components and nature of relationships underlying this model are considered relatively stable, their range, content, and relative power will vary over time. In addition to being dynamic, structuration is understood to be a dialectical process, hence inherently contradictory. In contrast to models that relate elements linearly, the structurational model assumes that elements interact recursively, may be in opposition, and that they may undermine each other's effects. An example is the tendency of technology to become reified in organizations, thus becoming detached from the human action that constructed it. The typical apprehension of technologies as given and objective directly contradicts their inherently constructed nature. Recognizing potential contradictions helps us to understand points of tension and instability in organizations, and how these may interact to change and transform organizations.

Using the Structurational Model of Technology

This section illustrates the structurational model of technology by interpreting the findings of a field research study (Orlikowski 1988), which investigated the use of information technology in a large, multi-national software consulting firm, Beta Corporation.

Research Site

In 1987, Beta earned \$600 million dollars in worldwide consulting fees and employed over 13,000 consultants in some 200 offices in over 50 countries. Most of Beta's employees are "functional consultants" who engage in the building of customized application systems for clients. A small proportion (three percent in 1987) are "technical consultants" who provide technical support (expertise in hardware and systems software) to the functional consultants, and engage in research and development. Beta consultants operate in temporary project teams and occupy various levels