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ORIGINAL ARTICLE

Crossing the Implementation Line: The Mutual Constitution of Technology and Organizing Across Development and Use Activities

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A growing number of studies suggest that technological change and organizational change must be closely linked at the microsocial level of analysis. However, most extant research has explicitly linked technological change to activities surrounding a technology's development and organizational change to activities surrounding a technology's use. This article suggests that when researchers view technological and organizational change as discontinuous events separated by the act of implementation, they discredit the important role that organizations play in the development of technologies, and that the material features of technologies play in the process of organizing. To overcome this empirically inaccurate tendency we must cross the artificial empirical and theoretical divide, which I term the implementation line *existing between our studies of technology development and use. In so doing, I outline a framework that treats technological and organizational change as mutually constitutive in nature.*

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Virtually all social research on technology and organizing—whether by promoting or denying it—owes some intellectual debt to technologically deterministic thinking. Early studies adopted a technologically deterministic perspective to provide causal explanations for organizational change (Ives, Hamilton, & Davis, 1980; Leavitt & Whistler, 1958; Swanson, 1974) and recent researchers have worked hard to falsify technological determinism's guiding propositions (Jackson, 1996; Latour, 2005; Leonardi, 2007; Orlikowski, 2000; Poole & DeSanctis, 2004). Today, as Winner (1998, p. 62) suggests, deterministic views of the relationship between technology and organizing are considered "laughable" as researchers consistently provide contextually specific accounts of the messy communicative processes by which the material and the social elements of technology and organizing become entangled.

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In their zeal to provide antidotes to technological determinism, however, students of technology and organizing scarcely pause to consider the effects that deterministic thinking has had and continues to have on theories of change. In this article, I suggest that the ways in which technological determinism has been defined and fought against over the last 2 decades have inadvertently disassociated our understandings of those microsocial activities surrounding a technology's development from those microsocial activities surrounding its use. In other words, the development of a technology is normally considered to reach an end when it is implemented in an organizational setting, at which time people begin using it. Mounting evidence to the contrary suggests that treating implementation as a point at which the development of a technology stops and its use begins is empirically inaccurate (Johnson & Rice, 1987; Lewis & Seibold, 1993, 1996; Majchrzak, Rice, Malhotra, King, & Ba, 2000; Rice & Rogers, 1980; Yates, 2005). Yet, by respecting this empirical and theoretical divide, which I term the *implementation line,* researchers often succumb to the temptation of viewing technological change synonymously with technology development, and organizational change synonymously with technology use.

The goal of this article is to show that it is empirically misleading and theoretically disadvantageous to make such arbitrary distinctions. When we view changes in technologies and the process of organizing as discontinuous events we discredit the important role that organizing processes play in the development of technologies and that the material features of technologies play in the process of organizing. Treating technology and organizing as if they were distinct processes may promote an impoverished understanding of the empirical relationship between the dynamics of a technology's development and use by leading researchers to make artificial distinctions between what counts as ''social'' and what counts as ''material'' in the communicative accomplishment of organizing (Taylor, 2006; Taylor, Groleau, Heaton, & Van Evry, 2001). As this article will show, making such distinctions is problematic not only for the ontological reasons discussed in some depth by actor-network theorists (e.g. Kaghan & Bowker, 2001; Latour, 2005; Law, 1992), but for empirical reasons as well.

I propose that to overcome such tendencies requires crossing the implementation line that exists between our understanding of the social construction processes of technology development and use. To do so requires understanding why the implementation line exists in the first place. Thus, I begin by discussing how two programs of research on technology (one promoted by science and technology researchers and the other by organizational communication and information systems researchers) have each developed mechanisms to combat deterministic thinking. I then discuss how the empirical foci of these social constructivist approaches have created and perpetuated the implementation line, and the consequences that this line has for understanding the relationship between technology and organizing. After explicating the problems that the implementation line poses for constructivist research, I outline a framework that accounts for the ways in which technological and organizational changes become mutually constitutive. Finally, I conclude by

suggesting that organizational communication researchers are uniquely positioned to study the mutual constitution of technology and organizing and suggest several avenues for investigating the interrelations between these phenomena.

Defining the concept of technological determinism

Generally, the determinist's thesis is underwritten by two guiding propositions. The first suggests that technological change occurs independently of human action. The second argues that organizational change is caused by the introduction of a new technology into an established social system (Bimber, 1994). Over the last 40 years, researchers across a number of disciplines have consistently defined these twin propositions in similar ways. Consider the following definitions spanning 4 decades of interest in technologically deterministic explanations of change.

Understood in its strongest sense, technological determinism stands or falls on two hypotheses: (a) that the technical base of a society is the fundamental conditions affecting all patterns of social existence, and (b) that changes in technology are the single most important source of change in society (Winner, 1977, p. 76).

> The first part of technological determinism is that technical change is in some sense *autonomous*, "outside of society," literally or metaphorically. The second part is that technical change *causes* social changes. (MacKenzie & Wajcman, 1985)

> (1) The nature of technologies and the direction of change are unproblematic or predetermined (perhaps subject to an inner "technical logic" or economic imperative, and (2) Technology has necessary and determinate "impacts" upon work, upon economic life, and upon society as a whole: Technological change thus produces social and organizational change. (Williams & Edge, 1996, p. 868)

> Generally, technological determinism is represented by either one of two beliefs. The first is the belief that technological development follows a trajectory that is intrinsic to the technology itself. Technology "advances," with newer artifacts replacing the old, on a progressive course. Denying technological advance is to intervene socially—which in this context means prejudicially—and to work against the natural order of the world. The second is the belief that technologies act upon the social world in predictable, inevitable ways. (Leonardi & Jackson, 2004. p. 674)

Technological determinism is a simple and elegant idea. As Smith (1994, p. 34) observes, it is also "heartbreaking in its simplicity." We are surrounded by explanations of social changes inspired by what Winner (1977) calls "technological animism" or the notion that technologies are acting agents in the world—they can "make" us do things or "prohibit" us from doing others.

Deterministic outcomes do appear quite natural and even predictable when examined at the level of social structure. Because most theories of macrosocial

change aim to explain alterations in social structure over extended temporal periods (sometimes epochs), they often focus on the moments/events to which particular outcomes can be traced. Because, in many cases, exogenous shocks to a social system come in the form of new technologies, historians and macrosociologists often posit a causal relationship between technology and changes in a social structure. As Bijker (1995a) notes, however, the problem with tracing outcomes retrospectively to crucial technological junctures is that investigators always suffer the temptation to blind themselves to the distortions that linear descriptions require.

The preferred antidote to this problem across a variety of disciplines has been to examine the relationship between technology and society at the microsocial level (with communication as the unit of analysis). From this vantage point, the relationship between technological and social change appears in much greater flux. The implementation of a new technology is an inherently political process in which technologies rarely seem to cause any immediate social transformations and are oftentimes resisted or subverted by those who incorporate them into their lives. As such, it becomes increasingly difficult to conflate technological and social change as macrosocial theorists often do. From such a perspective, this sociotechnical relationship appears anything but orderly. In this logic, no changes are ''inevitable'' or predetermined, but arise instead through the mutual interplay of material and social factors. Cause and effect are hard to untangle.

For researchers who adopt the view that macrosocial phenomena such as societies, cultures, and organizations are nothing but the medium and outcome of communicative activity, deterministic thinking is in fundamental opposition to their core ontological principles. Because conceptualizations of the relationship between technological and social change are so imbued with deterministic thinking in popular culture, and even in many positivist academic communities, the burden of proof that things are otherwise falls on the shoulders of the challenger.

Deconstructing determinism: Social constructivist approaches to technology development and use

Over the last 2 decades, two separate constructivist research programs have taken root to establish the empirical invalidity of technological determinism. Both have been concerned with debunking the notion of technological ''impact.'' Each program has worked to dethrone the rein of deterministic thinking by approaching one of determinism's two propositions at the relative exclusion of the other. Although many studies conducted within these two programs have focused on information and communication technologies, some studies have not. Regardless of their orientation, all studies define ''technology,'' at least provisionally, as a material artifact (e.g., hardware or software). Thus, the foregoing discussions in this article should be read to apply to technological artifacts generally, but may be most applicable to contexts in which information and communication technologies are developed and used.

Developing new technologies

The social constructivist program of research on the development of new technologies, associated with the work of historians and sociologists of technology and drawing its theoretical roots from the sociology of scientific knowledge, has attempted to deal with the notion of "impact" by focusing not on impact itself, but on the technologies that are said to "cause" those impacts. The logic is as follows: If technology has "impacts," those impacts are not "inevitable," but are preconfigured by those who are involved in the development of the technology. To this end, MacKenzie and Wajcman (1985, p. 8) note:

> Our focus—and where our criticism of technological determinism would centre—is on the assumption that technological change is autonomous, "outside" of the society in which it takes place. Our question is, what shapes the technology in the first place, before it has "effects?" Particularly, what role does society play in shaping technology?

Clearly, this approach takes direct aim at determinism's first proposition: That technological change follows some property intrinsic to the material features of the artifact. To fight this first proposition, researchers in this program have suggested that technological *development* always occurs within a sociopolitical context in which actors negotiate and use persuasive techniques to guide the evolution of a technology's material features. Thus, researchers have linked technological change to those activities associated with a technology's development.

Interest in fighting determinism's first proposition can be traced to the early to mid-1980s when researchers began to speak out against popular notions of innovation that suggested an abstract model of linear development. As Williams and Edge (1996) suggest, researchers of science and technology studies (STS) began to directly critique these models of linear innovation that were not only popular in academic communities (particularly economics) but were also prevalent in British government and industry in the 1970s and early 1980s precisely because they viewed particular paths of technological change as "inevitable" and impervious to competing interests.

Sociologists of technology drew on a number of ideas generated in the sociology of scientific knowledge. Bloor (1973), for example, argued that when investigating the causes of scientific beliefs, sociologists should be impartial to their truth or falsity and should attempt to explain them symmetrically. In other words, knowledge that is taken to be true, and knowledge that is taken to be false, are both susceptible to sociocultural explanation and that these explanations should be in the same terms. Within the sociology of scientific knowledge all knowledge and knowledge claims are treated as social constructions—facts are constructed through social processes rather than "natural" processes (Collins, 1981; Collins & Pinch, 1982; Knorr-Cetina, 1981; Latour & Woolgar, 1979). At the same time, a number of empirical studies began to examine the processes of technological development directly. Researchers

such as Layton (1971) and Callon (1980) showed that technologies rarely followed a process of linear innovation. Instead, they were subject to changes at many stages brought about by social and political interests in their development. Additionally, many authors began to consider that the design of particular technologies were value laden, benefiting some groups while marginalizing others (e.g., Braverman, 1974; Noble, 1979; Winner, 1980).

As Bijker, Hughes, and Pinch (1987) point out, constructivist studies of knowledge making and a renewed interest in the study of technological development led to the beginning of a research program on the social construction of technology development. Within this constructivist program we can distinguish three related attempts to fight against the first of determinism's two propositions regarding the nature of technological and social change: The social construction of technology approach, the actor-network approach, and the systems approach. Together, these theories "demarcate a research program studying the development of technological artifacts and systems . . . that aims at contributing to a greater understanding of the social processes involved in technological development" (Bijker et al., 1987, p. 10).

Social construction of technology approach

The initial formulation of the social construction of technology (SCOT) approach was offered by Pinch and Bijker in 1984. In their critique of deterministic models of evolutionary change, Pinch and Bijker (1984) proposed an alternative theory that explains how social practices shape the development of new technologies. In this model, "variation and selection" are the social practices constructing technological development that the authors wish to elaborate. The SCOT approach attempts to explain how these processes work by making several assumptions about the relationship between technology and society (Jackson, Poole, & Kuhn, 2002). The first is that the uses of a technology are not determined by a natural technological evolution, but are, instead, the result of the social and cultural practices that designers carry with them. The process of design is not arbitrary or determined by previous generations of the technology; rather, it is active in seeking to serve the interests of some over others. The second main assumption is that technological artifacts are unstable and are never complete. All technological developments are subject to change over time. Although a designer may build an artifact to accomplish a certain purpose, the ways in which various parties conceive of its use can shape further development of the artifact. As an example of this position, Pinch and Bijker cite the development of the safety bicycle at the turn of the 20th century as an example of an artifact that continually changed as different groups used it for different purposes. The authors trace the development of the bicycle from the initial "high-wheeler," a virile machine for sport rather than transport, to the "safety bicycle," a stable, safe vehicle for transport.

SCOT proposes four conceptual levers by which to study of technology development. The first is that *relevant social groups* play a key role in the development of a technological artifact. Such groups share a particular meaning of the artifact. This meaning then can be used to explain why artifacts develop along particular paths. Pinch and Bijker describe that there were at least two relevant social groups important to the development of the bicycle: ''young men of nerve,'' and ''older men and women.'' Each of these groups contributed to the development of the bicycle in different ways. Second, to understand how technology is socially constructed, one must keep in mind that all newly created artifacts are interpretatively flexible. *Interpretative flexibility* is the notion that the meaning of an artifact does not reside in the technology itself, but is determined by the meanings attributed to it by its relevant social groups (Pinch, 2003). Thus, there is an interpretative flexibility over the meaning to be given to an artifact. In the case of the bicycle, the high-wheeler simultaneously had the meaning of ''macho machine'' for young men and ''unsafe machine'' for older men and women. As a result, the one artifact itself was interpretatively flexible among the various social groups, and different meanings were embodied in new artifacts. The third mechanism is related to the second: All newly created artifacts reach a state of *stabilization and closure.* As Pinch and Bijker (1984, p.426) describe, ''closure in technology involves the stabilization of an artifact and the 'disappearance' of problems.'' Over time, the artifact stabilizes and interpretative flexibility is diminished as one meaning becomes dominant. Pinch and Bijker suggest that artifacts can reach a state of closure through two avenues. The first is rhetorical closure, whereby designers talk about the technology in a way that emphasizes its finality. The second is closure by redefinition of the problem. In this mechanism, designers begin to tackle a new problem of development, thus leaving the solution to the old problem satisfactorily behind, essentially closing further exploration into it. Bijker (1995a) later proposed a fourth conceptual lever to help understand the process by which technologies are socially constructed: *Technological frames* structure the interactions among the actors of a relevant social group. A technological frame is comprised of the elements that influence the interactions of a group of designers and leads to the attribution of meanings to technical artifacts. Bijker (1995a) cites the development of Bakelite as a process that occurred because of the technological frames shared between the developers of the technology. Goals of the production process, for example, focused on problems with the chemical composition of the material that then led to solutions that seemed ''necessary'' and ''inevitable.'' As a result, artifacts come to have their meaning by the technological frames through which they are interpreted. Thus, the technical and the social are intimately interrelated. However, the distinction between what counts as social and what counts as material still remains—a distinction that is obliterated in the actor-network approach.

Actor-network approach

Actor-network theory (ANT) emerged out of the work of Latour (1987), Callon (1986), and Law (1987) at roughly the same time as the SCOT approach. Working

separately and at times together, these authors criticized Pinch and Bijker's SCOT approach for making arbitrary distinctions between the social and the technological in their explication of the stabilization of technologies. ANT's main proposition is that the split between technology and society is artificial. To reconcile these two entities, ANT focuses on multiple networks that are composed of (human and nonhuman) actors who share the same ontological status. In other words, there is no social/technical distinction. Neutrons, scallops, people, and organizations are all treated as similar semantic components capable of influencing an actor-network. While still seeking to explain how the process of technological development unfolds, ANT's supporters argue that a social constructivist theory of technology must take into account the status of the actors involved throughout the technology development process and the study of the "social" not as the characteristics of any one individual but, rather, as a distinct network in which heterogeneous relationships constitute different actors (Kaghan & Bowker, 2001).

ANT proposes two major concepts by which to understand the social construction process. The first concept is that of *translation*. Callon and Latour (1981) suggest that translation is the process of negotiation whereby actors (human or nonhuman) assume the authority to speak and act on behalf of others. Callon (1986) later specified that translation involves at least four distinct subprocesses. In the first, problematization, actors position themselves as resources for problem solving by foisting their definition of a given technological problem onto other actors. In the second, interssesment, actors attempt to build alliances with other actors and with those actors who have not yet become members of the actor-network in order to validate a proposed problematization. The third, enrollment, involves multilateral negotiations used to help an interssesment succeed—pointing new actors toward a desirable end state and showing them the means to achieve this goal. Finally, mobilization is a set of strategies that actors use to ensure that those allies they have enrolled do not betray their interests. Because different sets of actors often have diverse interests, the development of a technology rests on the ability to translate—reinterpret, re-present, or appropriate—others' interests to one's own (Law, 1992). As Callon (1991, p. 143) suggests, translation presupposes a medium into which such negotiations are inscribed: Translations are "embodied in texts, machines, bodily skills [that] become their support, their more or less faithful executive." Although the definition and process of translation is often murky within ANT research, it is generally viewed to be a political process whereby actors use any means at their disposal to build a network of heterogeneous actors that will ultimately allow a technology to develop in a certain desired direction. The second concept, *inscription,* refers to the process by which individuals embed their social agendas into artifacts. As Latour (1991) suggests, all developers have certain "programs"—ideas about what they want the technology to do—and once this program is "translated" into a set of negotiations that will make this possible they are then inscribed into the technology. The inscription includes programs of action for the users, and it defines roles to be played by users and the technology (Holstrom & Robey, 2005). In doing

so it also makes assumptions about the competencies required by users to use the system. Thus, by inscribing programs of action into a technology, the technology becomes an actor in and of itself, imposing its program of action on its users.

Systems approach

Large-scale systems theory, developed by Thomas Hughes (1983, 1986, 1987), is also interested in how technologies gain their meaning over time. It joins ANT in criticizing SCOT for being too concerned with independent artifacts and proposes that artifacts should be understood as elements in a system of corresponding elements. For Hughes, a system is a set of organizations, rules, artifacts, and procedures that co-create and reinforce one another. He argues that an artifact is created and perpetuated through a system in which various parties have an interest in a technology's development. The notion of "system" in this theory is distinct from the notion of "network" presented in ANT because a system "has an environment—a remaining outside—that a network does not" (Hughes, 1986, p. 290). Once a technology is developed and achieves closure, it can culminate in a technological system of its own with other elements in the system helping to keep the artifact in the forefront of the developmental process—"they have a mass of technical and organizational components; they possess direction, or goals; and they display a rate of growth suggesting velocity" (Hughes, 1987, p. 76).

In the formulation of the systems approach, Hughes suggests that to understand the development of new technologies requires attending to at least two important concepts. First, to understand the creation of technological systems one must be attuned to the inadvertent creation of the *reverse salient.* A reverse salient is an inadequately functioning component in a complex system. Reverse salients are problems that inventors focus upon and often solve. Quite often, a reverse salient arises as an unanticipated outcome of a developing technological system. Hughes (1983) suggests that after Edison introduced direct current electricity in 1881 to light the Wall Street District in Manhattan, other competing investors quickly recognized a reverse salient: Direct current could not be transmitted economically for more than a mile or so, thus limiting the area that a power generating station could supply. This "problem" was eventually "solved" when Westinghouse introduced alternating current systems that could economically transmit electricity at high voltage over many miles. Thus, reverse salients often direct attention to the next technological "problem" to be solved by indicating a gap or malfunction in the current system. Hughes suggests that reverse salients are compelling precisely because they point to the fact that new technologies and the systems in which they are created and perpetuated have *momentum.* Hughes (1994) suggests that as new technologies and their systems develop they have a quality that is analogous to inertia of motion. In other words, because a technology develops and suggests reverse salients, new technologies are developed, which, in turn, suggest further reverse salients. Future change thus appears natural and makes it difficult to veer from the inertial path. The consequence is, as Hughes (1987, p. 76) suggests, that a high level of momentum "often causes

observers to assume that a technological system has become autonomous.'' Thus, developers often continue down a certain path, even though there are a number of reasons to suggest that they should not (Hommels, 2005).

Using new technologies

Social constructivist studies of technology use, associated with the work of organizational communication theorists, and drawing their theoretical insights from a variety of sources, including symbolic interactionism, ethnomethodology, and structuration theory, have worked to describe technological ''impact'' by focusing on the recipient organization rather than on the formation of the technologies that do the impacting. The logic to this approach is also quite simple: If technology has ''impacts,'' those impacts are mediated by the systems of meaning and interpretation into which the technologies are introduced. As Thomas (1994, p. 4) suggests:

> To explain what new technology does to organizations—or as it is commonly put, ''how technology impacts organizations''—we must also explain what people are trying to do to organizations, and, by extension, to themselves by means of new technology.

This approach places determinism's second proposition squarely in its sights: That technologies affect organizing processes in predictable ways. It suggests that changes in the process of organizing are not prefigured by a technology's material features, but are enacted while people are physically engaged in the *use* of a technology. By focusing on the power of human agency to create and change social orders, researchers in this program have linked organizational change to the ways people use the features of a new technology.

Social constructivist studies of technology use have been taken up primarily by organizational communication and information systems researchers who responded to the early work of organizational contingency theorists, who themselves strongly advocated a perspective on the relationship between technology and organizing that expanded determinism's second proposition. Contingency theory proposes that there is no single organizational structure effective for all organizations (Perrow, 1970). Because organizations are protean, membership can constantly change along with organizational strategy, purpose, size, new ideas, new technologies, and many other factors. In effect, organizational structure and form are contingent upon factors not inherent to the organization, factors that are products of the external environment. From a perspective of contingency theory, the relationship between an organization and its external environment is unidirectional. Environmental factors, such as new technologies, have the power to alter the structure of an organization, but the relationship does not work in reverse (Thompson, 1967; Woodward, 1958). Lawrence and Lorsch (1969, p. 10) offer an explanation as to the nature of this relationship: ''A machine cannot alter its gear train, an animal cannot develop an extra leg, but an organization can and does do analogous things.''

Because organizations are dynamic structures operating in a certain space and time they are susceptible to outside influence. Pursuant to this logic, contingency theory explains that organizational systems have the property of interdependence of parts, insomuch as a change in one part has an impact on the structure of the organization. Technology is thus an external, environmental factor upon which organizational structure can be contingent. Operating from within this perspective, technology is static and unchanging while organizations are dynamic and capable of adjusting their boundaries.

Dissatisfaction with these stances and the contradictory outcomes they suggest has led researchers to a more balanced view of the relationship between technologies and the organizations into which they are introduced. To be sure, contingency theorists conceptualized organizations as malleable but relatively stagnant entities (Hunt, 1970; Mohr, 1971). Beginning with Barley's (1986) introduction of a sequential model of structuring in studies of technology use, organizational researchers have adopted notions of negotiation, interaction, and structuration to suggest that organization (the noun) implies an unduly static entity, while organizing (the verb) implies a dynamic process. Using the verb reminds researchers that organizing is always in flux, and never stable. Many communication researchers have advanced this social constructivist view, suggesting that communication is the fundamental process through which organizing is accomplished. In so doing, they have expanded the notion of communication as something that occurs within predefined organizations to a conceptualization of communication as a process that enables organizing (either formal or informal) to occur (Heaton, 1998; Jackson, 1996; Poole & DeSanctis, 1992; Rice, Collins-Jarvis, & Zydney-Walker, 1999; Taylor & Van Every, 2000; Walther, 1995). Because organizing is always susceptible to change, researchers can comfortably view newly implemented technologies as change-agents without having to subscribe to a deterministic ontology.

The broad program of social constructivist research on technology use attempts to dislodge determinism's second proposition by carefully describing the interaction of technology's material properties with the communicative contours of the organization in which it is used. Generally speaking, we can distinguish three broad theoretical attempts at this goal: Social influence approaches, structuration approaches, and role-based approaches. At a general level, these approaches all acknowledge that although technological artifacts have material "properties that transcend the experience of individuals and particular settings" (Orlikowski, 2000, p. 408), of interest to this broad research program is how those properties become interpreted, understood, used, and reinforced by their interaction with features of the social system into which they are implemented. The consistent finding, which is reproduced across these approaches, is that social context moderates or buffers the effects the technology has on the organization of communicative practice.

Social influence approach

In their attempt to explain how individuals' perceptions toward new technologies are formed, Fulk and colleagues developed a social information processing model of technology use. Drawing on the insights of social information processing theory, the model proposes that perceptions of the objectivity, saliency, and rationality of a newly implemented technology are formed "to a substantial degree by the attitudes, statements, and behaviors of coworkers" (Fulk et al., 1987, p. 537). The model highlights the fact that individuals choose to use new technologies based on the ways in which their *perceptions* of them are influenced by social processes. Researchers look at the frequency (Rice & Aydin, 1991), intensity (Fulk, 1993), directionality (Fulk, Schmitz, & Ryu, 1995), and proportionality (Kraut, Rice, Cool, & Fish, 1998) of communication among users to understand why certain perceptions develop about new technologies. The process that communication is believed to facilitate is one of social influence (e.g. Fulk et al., 1987). In this perspective, however, social influence is never observed directly, but rather indirectly inferred from the types of communication in which organizational members engage. Fulk (1993), for example, showed that as one's attraction to his or her work group increased, one's attitudes and behaviors toward a new technology became more similar to those of that group.

Social influence models focus primarily on the adoption of a new technology. Recognizing that organizational implementation of a new technology does not necessarily mean that individuals will readily adopt it (Lewis, Agarwal, & Sambamurthy, 2003), the key empirical focal point is the process by which perceptions occasion common behaviors toward the technology. The majority of studies work to uncover how such perceptions correlate with technology use. Accordingly, the primary dependent variable of interest is the use of a new technology, normally measured either as a nominal or an ordinal variable. Consequently, the studies are more concerned with whether a new technology is used at all than with how it is used. The insight that a technology is socially constructed through social influence processes that encourage users' perceptions to grow common has been a key step in explaining why technology implementation efforts are sometimes successful, sometimes not.

Structuration approach

Over the past 20 years, a number of influential studies have used structuration theory (Giddens, 1984) to explore the links between new technological artifacts and the social contexts into which they are introduced (e.g., DeSanctis & Poole, 1994; Orlikowski, 1992, 2000; Poole & DeSanctis, 2004). Structuration theory's ability to simultaneously account for the purposive actions of technology users on one hand, and the consequent structuring of organizational practices triggered by new technologies on the other, has been a valuable interpretive framework that has allowed researchers to escape the perils of determinism's second proposition. Structuration models generally focus directly on how organizational members appropriate a

technology in ways that align its features with their existing work practices. The basic underlying premise of this approach is that *appropriations* of a technology are constitutive of macrosocial structures (such as organizational form). This means that as individuals appropriate the features of a new technology, and by association reproduce or change their work practices in the presence of the artifact's constraints and affordances, they are either reproducing or changing the structure of their organization. In other words, because communication is a constitutive feature of the organizing process, the action of using a new technology can thus be seen as a structural property of organizing.

Two streams of research using structuration models can be distinguished. First, adaptive structuration theory (AST) has evolved primarily from the work of Poole and DeSanctis (DeSanctis & Poole, 1994; Poole & DeSanctis, 1990). The premise underlying this perspective is that certain structures for use are built into a technology, and that when individuals encounter those structures, they appropriate them in ways that are consistent with existing organizational and group requirements. AST aims to take seriously the interactions between the deep structures that constitute technological artifacts, organizations, and work groups. Researchers using AST take norms for communicative interaction as the modality by which structuration is accomplished. Not coincidently, the types of technologies studied are ones in which specific norms for interaction are "designed-in." Group decision supports system (GDSS) and online collaboration tools, for example, are specifically designed to promote certain idealized communication patterns (e.g., Gopal & Prasad, 2000; Majchrzak et al., 2000; Poole & DeSanctis, 1990). Thus, research in this stream examines the assumptions about social interaction that are embedded in the technology as well as the norms for social interaction that exist within a group, organization, or occupation prior to its use of the technology (Contractor & Seibold, 1993; Zack & McKenney, 1995), and explore how the latter influences the appropriation of the former. The most robust studies in this perspective (e.g., Majchrzak et al., 2000) map how the norms for interaction within a social group generate the appropriation of the features of a technology over time.

The second stream has evolved primarily from Orlikowski's (1992) "duality of technology" model. As defined by Orlikowski (2000, p. 407), research in this stream "starts with human action and examines how it enacts emergent structures through recurrent interaction with the technology at hand." Accordingly, the majority of studies follow a two-step process. First, they seek to uncover the ways in which users "call forth" specific features of a technology through their repeated use of them in recurrent social practice. Second, they explore how those newly constituted features change the existing work practices conducted by individuals within the organization. Although AST provides solid evidence that certain outcomes of technology implementation are constructed, it rarely shows how or why they are. The duality of technology model attempts to overcome this problem by examining how practices of technology use might affect and be affected by norms for

communication that define the organizing process. Researchers in this stream begin their investigations into the social construction process by examining the situated and recurrent work practices that organizational members routinely conduct. Sedimented in these work practices are organizational objectives (Orlikowski, 1992), templates for interaction (Orlikowski, 1996), and conceptualizations of solutions to relevant organizational problems (Boudreau & Robey, 2005). Thus, each time a practice is enacted, particular features of the organizing process are reproduced (Orlikowski, 2000). As particular structures of technology use are enacted, the work practices through which they are created change slightly. Over time, gradual changes in work practices produce alterations in the social structure of which they are constitutive. Thus, the construction process is one in which numerous small improvisations in the appropriations of a technology result in changes of the macro-organizational structure that become sedimented once again in new work practices.

Role-based approach

Another set of studies conceptualizes technology use as a socially constructed process occurring through the alignment of technological structures with existing social structures. Typically, these social structures are represented as the ''roles'' and ''role-relations'' that are enacted in the everyday context of work. This perspective lifts its gaze from the micropractices of use represented in the structuration models and focuses on a meso-level examination of how newly implemented technologies influence and are influenced by individuals' *interactions* around the new technology. Newly implemented technologies serve as ''occasions'' for triggering structural changes, rather than as determinants of them (Barley, 1986). In this way, technology implementation is socially constructed as certain exogenous social forces set the conditions for the effect the technology will have on the organization of work.

Research using role-based approaches to the study of new technology implementation has focused on the relationships between members who are fulfilling different roles (Barley, 1990; Black, Carlile, & Repenning, 2004), the creation of new roles as a consequence of the change effort (Edmondson, Bohmer, & Pisano, 2001; Leonardi, 2007; Robey & Sahay, 1996), and the adaptation of existing roles to accommodate the physical demands of the new technology (Zuboff, 1988). Barley's (1990) analysis demonstrated that the social interactions between radiologists and technologists set the initial conditions for the effects that the new technology would have on the organization of work. In other words, social processes buffered the effects of the technology and constructed their outcomes. Thus, as exogenous social changes triggered by the introduction of a new technology altered the composition of the technicians' work roles, these nonrelational elements ''spilled over'' into the corresponding system of role relations and altered the informal organizational structure. Over time, this structure created new social forces that mediated the technology's ongoing impact. In short, this approach does not simply describe what norms for interaction are, but traces the evolution and change of actual patterns of interaction over time. By focusing so heavily on social interaction, however, such

research largely overlooks the micropractices of technology use that structuration models capture. Such social processes are taken for granted in this approach and assumed to influence interactions among individuals, although such influences are not directly shown.

The implementation line as an unintended consequence of programs of research

As the foregoing discussion demonstrates, researchers attempting to show that technological change is a socially constructed microsocial process have generated a number of mechanisms to explain how technologies are developed. Importantly, mechanisms such as *negotiation*, *closure*, *inscription*, and *momentum* all indicate that the social processes surrounding a technology's development eventually come to an end. Because each of these mechanisms enables technological change, the implication of their gradual dissipation is that technological change is seen to end once development activities cease. For such researchers, implementation marks a natural closing point into investigations of technological change. That is, those who posit social constructivist accounts of technological change rarely develop any sophisticated notion, or often even notice, that the technology has a new life in the organization into which it is introduced (Mackay, Carne, Beynon-Davies, & Tudhope, 2000, p. 749). Conversely, researchers attempting to show how technology use is socially constructed normally begin their empirical examinations only after a technology has already been implemented (Thomas, 1992, p. 443). Thus, the physical features of a technological artifact in this perspective are usually considered stable and unproblematic while the *perceptions*, *appropriations,* and *interactions* that individuals generate in response to that technology are seen to evolve and change over time.

What we begin to see by looking at the ways in which each program has dealt with the problem of determinism is that they have separated themselves from each other by the construction and perpetuation of what I term here an *implementation line*. Implementation is a common term. In its most recognized form the verb "implement" means "to put into practice." Such a definition suggests that there is some "thing" that will be put into practice. Thus, there is an implicit distinction between "things" and "practice." With these two domains, conceptually established implementation is neatly viewed as the "putting together" of these hitherto separate spaces. We can then say that the processes of *development* and *use* of a technology are, in most contemporary conceptualizations, separated by an implementation line. Thus, technological and organizational changes are often depicted as nonoverlapping, temporally sequenced events separated by an artificial implementation line.

The concept of the "black box" described by both research programs illustrates and reinforces the notion of an implementation line between the development and use spaces in which technology and organizations interact. As Winner (1993, p. 365) suggests:

> The term *black box* in both technical and social parlance is a device or system that, for convenience, is described solely in terms of its inputs and outputs. One

need not understand anything about what goes on inside such black boxes. One simply brackets them as instruments that perform certain valuable functions.

The social constructivist position argues that uncovering what goes into black boxes is essential for untangling the relationships between technological and organizational change. Researchers in the development space are immensely curious about black boxes. Williams and Edge (1996) suggest that the broad array of researchers who oppose deterministic critiques of the development of new technologies are united by an insistence that the black box of technology must be opened to allow the socioeconomic patterns embedded in both the content of technologies and the process of innovation to be exposed and analyzed. Bijker (1995b, p. 256) similarly reminds that the goal of constructivist research into the development of new technologies is to "pry open the black box of technology and to monitor the evolution of sociotechnical systems." Accordingly, studies of technology development normally begin with a technology that is already a black box and then work backward to open it up. In other words, they often begin by taking a technology that is for all intent and purpose "done" and moving backward through its evolution to uncover the social practices that led to the choice and stabilization of various technological features. The goal is not necessarily to show how it becomes closed, but rather to show that technology is not really a black box at all—there is no mystery or magic, just the negotiations among interested actors that become obscured and forgotten over time. The history of a technology can thus be reread not as a history of linear evolution, but as an alternation of variations and selections (Pinch & Bijker, 1984). It should come as no surprise that the overwhelming majority of development studies are constructed through retrospective histories of change in the technological and social orders.

Researchers in the use space are also concerned with the same black boxes. Their inquiry, however, recognizes that a technology enters a social context as a black box, and that to understand how it changes the process of organizing requires opening up the black box to demonstrate that it has no meaningful existence outside the context of use. As Orlikowski (2000, p. 412) suggests, "technologies are thus never fully stabilized or 'complete,' even though we may choose to treat them as fixed, black boxes for a period of time." This is because people can and do often use one technology in radically different ways. The finer point to be taken from this suggestion is that the functionality of a technology—the ability of an artifact to be used to accomplish a social task—does not exist outside of a situated context of use. In other words, our expectations of what features a technology has, what those features are good for, how they should be used, and how they will change the way we work (all of which we draw from the culture in which we encounter the technology) buffer our perceptions of the material elements, those elements of the technology that do not change across contexts of use. As Jackson (1996) suggests, the act of identifying or perceiving a technology is part of that technology. For this reason, studies of technology use also begin with a closed black box. But instead of tracing

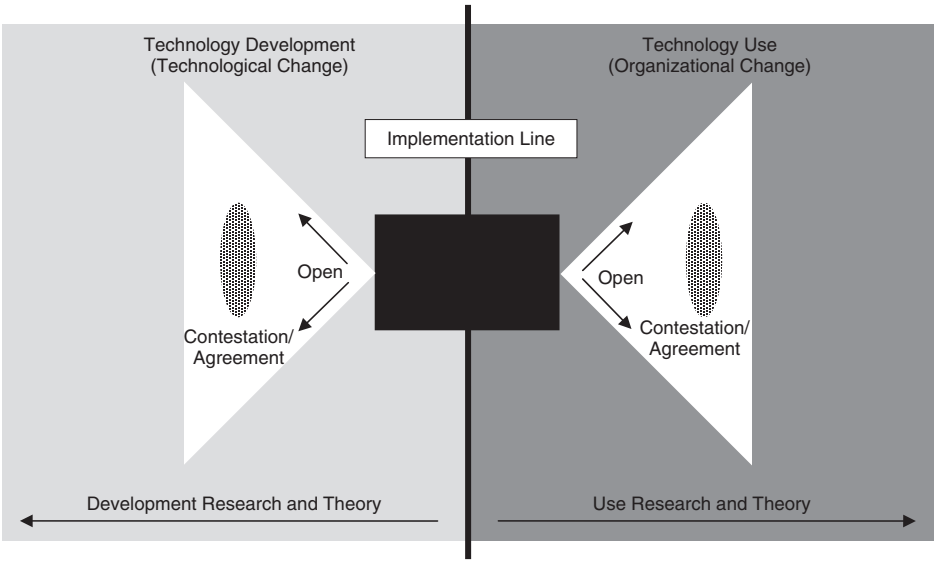

Figure 1 Opening up black boxes: Two social constructivist programs of research.

its history backward they trace it forward, opening it up to reveal that although the actual physical features of the technology have stopped evolving, the uses to which those features are put and the outcomes those uses create have not.

As Figure 1 illustrates, conceptualizing development as ending with a black box, and use as beginning with one, means that the implementation line—that space between development and use—becomes an important empirical and disciplinary divide. This means that for development researchers technological change is conceptualized to occur, and is therefore only of empirical or theoretical interest, *before* the implementation line. Conversely, for use researchers the ramifications for the ways individuals use a new technology, and consequently any interest in the implementation process, typically begins *after* the implementation line.

Why is the implementation line problematic? Recent empirical work has begun to report that changes in organizing affect how technologies are developed (Klein & Kleinman, 2002; Mackay et al., 2000; Orlikowski, 2000; Poole & DeSanctis, 2004; Vaughan, 1999)—organizational change happens during the process of technology development—and that implementers and users of technologies contribute to technological change (Lewis & Seibold, 1996; Lindsay, 2003; Oudshoorn & Pinch, 2003; Pollock, 2005; Yates, 2005)—technological change happens during the process of technology use.

Although no researcher on either side of the implementation line would deny that social processes are transpiring around the technology on the other, the image with which we are left as we attempt to appreciate the social construction process is dark and fuzzy. Do technology and organization have a punctuated flow? Does social construction occur while a technology is developed, then stop only to start up again

when the technology is taken up in the context of use? Do those social construction processes that result in the creation and stabilization of a new technology have any bearing on the way that technology use is socially constructed? These are important questions, but currently there are few studies that have crossed the implementation line to be poised to answer them. The theoretical insights and strategies for research generated on one side of the line do not always neatly correspond to activities on the other. Further, empirical studies that follow a technology and an organization from the earliest days of conceptualization through an extended period of use are virtually nonexistent. Integrating the two constructivist programs of research seems essential to generating theory and practice on technological and organizational change that is useful, actionable, and interesting.

Crossing the implementation line

To cross the implementation line and move toward a view of technological and organizational change as mutually constitutive in nature researchers must examine the relationship between three broad sets of activities through which technology and organizing processes become entangled: Activities surrounding a technology's development; those activities surrounding its implementation; and those activities surrounding its use. To do so, researchers must take not only a diachronic perspective (e.g., how technologies and organizing processes co-evolve over time within one set of activities), but also a synchronic perspective that examines how the interplay between technology and organizing occurring during one set of activities (e.g., use) affects processes that are conducted simultaneously by other actors (e.g., development) (Barley & Tolbert, 1997).

First, a diachronic explanation of mutually constitutive change would recognize that technologies and organizations co-evolve over time within a given set of activities. The nested model in Figure 2 illustrates this process. Those who develop, implement, and use new technologies do so within the broader context of the organizing process. Developers of a new technology are enabled and constrained by the institutional properties of their work (Klein & Kleinman, 2002; Orlikowski & Robey, 1991) and they often inscribe those properties into the artifacts themselves (Holstrom & Robey, 2005; Walsham, 2002). Similarly, users of a new technology are enabled and constrained by their participation in the process of organizing (Contractor & Eisenberg, 1990; Rice & Gattiker, 2001) and they use the material features of a new technology as resources with which to change those actions (Boudreau & Robey, 2005; Leonardi, 2007).

From the constructivist program on technology development we know that the microprocesses occurring around a technology (depicted in the medium-gray circle of Figure 2) are characterized by contestation and agreement. There are many diverse *groups* associated with a technology, and each group has a unique reason for wanting to see technology change (Rosen, 1993). Thus, pressure often builds among relevant social groups. This pressure can lead such groups to identify different

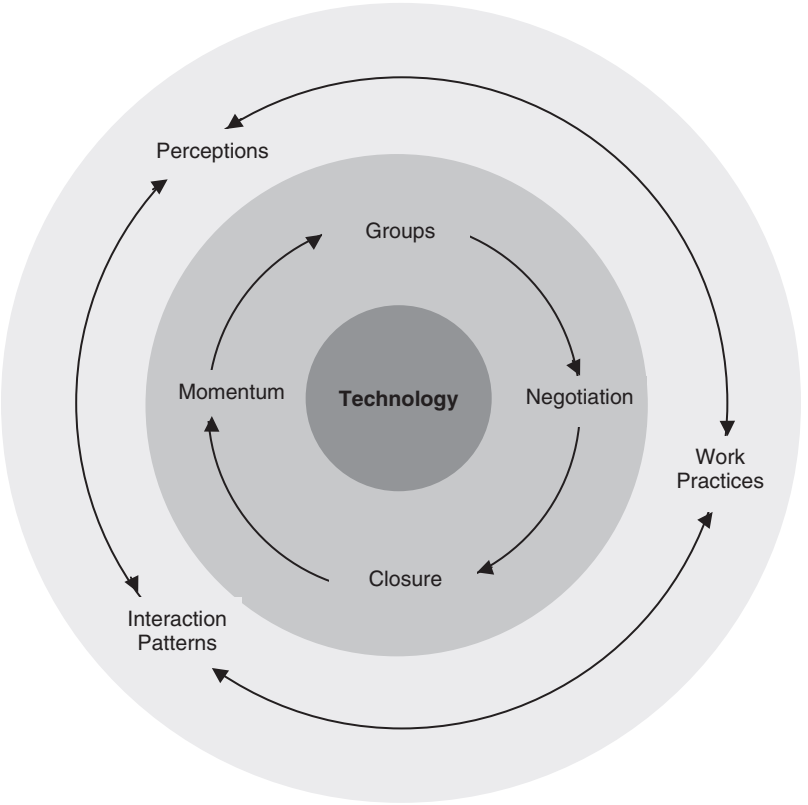

Figure 2 Integrating concepts from constructivist programs.

reverse salients (Hughes, 1987) and *negotiate* their interests into alignment through persuasive campaigns (Callon, 1986). In so doing, they continually shape and reshape a technology's interpretive flexibility (Kline & Pinch, 1996). As contestation turns into agreement the technology moves toward a temporary state (Klein & Kleinman, 2002) where its "working" becomes, at least among those groups involved in the activities transpiring around it, relatively uncontestable (Pinch, 2003). With these controversies solved, particular ways of thinking about and relating to the technology gain *momentum* (Hughes, 1994) and the enactment of technological frames makes it difficult for actors to conceptualize the technology in a different way (Bijker, 1995a). From the perspective offered by social constructivist researchers of technology use we may surmise that these microprocesses of contestation and agreement are embedded in a larger process of organizing (depicted in the light gray circle of Figure 2) that constrains and enables them in at least three ways: Through a community's shared *perceptions* (Fulk, 1993; Kraut et al., 1998); the *appropriations* they make of the technology (Poole & DeSanctis, 1992; Scott, Quinn, Timmerman, & Garrett, 1998); and their patterns of *interaction* around the technology (Aydin & Rice, 1992; Barley, 1990). These activities, which serve as resources individuals draw on in the process

of organizing, color their understandings of what groups should be involved in the development, implementation, or use of a technology, what the technology should look like, what it should do, and how it should change existing practices. In their reinforcement of one another, perceptions, appropriations, and interaction patterns condition how members of a particular group will interact with the technology, and in so doing, how the technology will change the organization of work.

Taken together, these insights from the heretofore distinct social constructivist programs on technology development and use suggest that the development or use of a technology always takes place within the confines of the actions of organizing. Therefore, as organizations change, those actions associated with their production and reproduction will change technologies, and as technologies change, those actions surrounding them will change the organization. For example, by looking at Figure 2, one could imagine that a change in a technology is achieved by moving from the outermost circle (light gray) inward. Organizing processes enable and constrain those microsocial activities that directly affect a technological artifact's form and function. Conversely, one could imagine that a change in organizing processes occurs by moving from the innermost circle (dark gray) outward. When an artifact occasions changes in the microsocial activities transpiring around it, such alteration in communicative activity enacts changes in the process of organizing. Thus, from a mutually constitutive approach, changes in technology and the process of organizing result from reverberations in both directions. Such a view pushes researchers to conceptualize the interaction effects between technologies and organizations rather than allowing them to consider organizations as a mere backdrop of technological change, or organizations as the mere backdrop of technological change.

Whereas a diachronic approach shows that within a particular set of activities (i.e., technology development, implementation, and use) technological and organizational changes become mutually constitutive over time, a synchronic approach suggests that the ways in which the material properties of technologies and the actions of organizing become entangled within one set of activities has consequences for how they are entangled across others occurring at roughly the same time. For example, very recent research is beginning to suggest that there is no neat and tidy division between activities surrounding technology development and use. Such work by technology development researchers who study Web-based publishing (Boczkowski, 2004), personal computers (Lindsay, 2003), the telephone (Kline, 2003), and audio synthesizers (Pinch & Trocco, 2002) has shown how users themselves can suggest new features for future technological development. Also, recent work by technology use researchers is beginning to question the ways in which technologies are developed, as misalignments between the technology's features and those who use them become more apparent (Boudreau & Robey, 2005; Rice et al., 1999; Tyre & Orlikowski, 1994).

A technology has varying consequences and is shaped in different ways as these interrelated activities transpire around it. Development activities often begin with individuals looking at a technology currently in use or with a set of ideas about how a new technology could change the way work is conducted. Understanding

the problems that need to be solved in the development of a new technology requires opening up that black box and submitting its contents to negotiation among those groups involved in the developmental process (Bijker & Law, 1992). As those negotiations and the contestation they encourage begin to die down, the technology can begin to stabilize and new groups can become involved. These new groups often consist of trainers, managers, marketers, and all those who take this new technology and introduce it into the community of users (Pinch, 2003; Thomas, 1994; Yates, Orlikowski, & Okamura, 1999). These groups must open up the quasi-black box given to them by the developers and begin to negotiate about what the technology is, what it does, and how they will communicate these goals to users. Their eventual agreement results, once again, in the closing of the technology and the hardening of its meaning. During this time, users begin to interact with the technology. It confronts them as a settled and stable black box, but through the demands of their sociocultural context they, too, open it back up and make interpretations about what it is good for, how to use it, and how it will change their work (Grint & Woolgar, 1997; Vaast & Walsham, 2005). As these negotiations settle and new and potentially controversial uses of it come to appear less and less feasible, the technology again becomes a black box. When the flexibilities of a technology's use are diminished, the time is often ripe for development activities to begin again, sometimes through user modifications (Johnson & Rice, 1987; Lewis & Seibold, 1993) and other times through more formalized redevelopment processes (Christensen, Anthony, Berstell, & Nitterhouse, 2007; von Hippel, 1988). These new development activities often attempt to address the misalignments between the technology's physical features and the way it is being used. Consequently, the process begins anew.

Framing the change process as mutually constitutive moves us from conceptualizing technological and organizational change as separate and distinct phenomena. No set of activities occurs in isolation from others. Developers provide templates for trainers and managers to interpret new technologies (open the boxes) and trainers and managers do the same for users. Researchers must recognize that although these sets of activities often have a temporal sequence (i.e., development → implementation → use) they also frequently occur simultaneously and interactively. In short, the activities surrounding development, implementation, and use are related, they often overlap, and they influence each other through the choices made within and between the communities that come into contact with the technology.

Implications for theorizing about technological and organizational change

The framework outlined above combines the empirical insights from each program of social constructivist research to explain the mutually constitutive relationship between technologies and organizations diachronically and synchronically. This section explores what communication researchers might gain by crossing the implementation line and treating technological and organizational changes as mutually constitutive in nature.

One strength of the mutually constitutive approach is that it begins to break down two dichotomies that have long been conflated in writing on the social construction of technological change: Technology and organizing, on the one hand, and development and use on the other. As the foregoing arguments suggest, the conflation of these dichotomies fails to remain convincing when challenged with empirical evidence. Changes in the process of organizing do occur when people are involved in activities surrounding the development of a new technology and changes in technology's form and function routinely arise as people actively use a technology in the context of their work. By combining the evidence from social constructivist researchers who have battled each of determinism's twin propositions, the mutually constitutive approach suggests that technology-organizing and development use may themselves be unwarranted dichotomies.

In considering the first dichotomy—technology-organizing—proponents of the social influence, structuration, and role-based approaches have gone to great lengths to treat organizing as a process, rather than an outcome. By treating organizing as a process, they have emphasized that the entities we call organizations are social constructions that are continuously being redefined through communication practices that are enabled and constrained by the technologies people use. We lack a similar linguistic way to transform the noun "technology" into a verb, and thereby emphasize that it is always in flux, susceptible to redesign or reinvention throughout its lifecycle. The inability to turn "technology" into a verb is likely a good thing because it forestalls researchers from finding a new way to keep it analytically separate from the concept of organizing. Even if we could pull a linguistic sleight of hand and make the noun into a verb, we would still only be reinforcing the notion that even though they are both dynamic processes, technology and organizing are analytically distinguishable. After nearly a quarter-century of constructivist research we know that such a notion is problematic precisely because authors describe technologies in the same way that they describe the organizing process: As a constellation of social and material elements. In other words, technologies are as much social as they are material (in the sense that material features were chosen and retained through social interaction) and organizations are as much material as they are social (in the sense that social interactions are enabled and constrained by material properties). Recently, authors such as Latour (2005), Taylor (2006), and Leonardi (2009) have begun to suggest that although people can point to some things that are "social" and to others that are "material," social and material forces do not exist independently. Instead, the social and the material interact with one another continuously so as to make them difficult to untangle. If the interaction of the same social and material practices constitutes technologies and organizations alike, then making a categorical distinction between technological and organizational changes may be short-sighted.

Many years ago, sociotechnical systems theorists attempted to raise the awareness that such dualisms were problematic and promote a view of organizing as a sociotechnical process (Emery, 1959; Trist & Bamforth, 1951). However, sociotechnical systems researchers treated the social and technical elements of people's

work as distinct systems, thus reinforcing a practical and analytical distinction between them. Today, most researchers agree that a technology has no meaning or purpose outside of its social context of development or use, and most would be uncomfortable proffering a definition of technology as a material phenomenon and organizing as a social one. To do so would be to deny the important role that social processes play in technological change, and material processes play in organizational change. The mutually constitutive approach moves such thinking a step further by suggesting that if technology is a sociomaterial process and organizing is a sociomaterial process, too, there exists no important distinction between technological and organizational change. That is, the appropriate unit of analysis for "technology" is the artifact *and* the people interacting with it and around it, and the appropriate unit of analysis for "organizing" is people interacting with each other *and* the artifacts that enable or constrain their interaction. Although technologies and organizing might be analytically indistinguishable, the elements constitutive of them both—an artifact's features and people's interactions—are not. In a pragmatic sense, artifacts have features regardless of whether people use them and people's interactions can be empirically differentiated from the artifacts they use. The point is not to replace the concept of "technology" with that of "artifact," or the concept of organization with "interaction," but rather to suggest that by identifying those core components that are constitutive of both technologies and organizing, and studying how they mutually influence one another, we can begin to show how the social and material elements of work constitute technologies and organizations alike.

Linking social and material elements in this way may provide researchers with a framework with which to begin addressing the fundamental interdependence between them in the process of organizing. If changes in an artifact's material features provide people with new capabilities that they did not have before, such affordances may enable changes in a group's pattern of interaction. Yet the range of possible uses of a technological artifact is circumscribed by the finite character of its materiality. Thus, to some extent, the materiality of an artifact may set the limits for social change by providing only certain capabilities and not others (Leonardi, 2009). As individuals use those features of the artifact to do new things, or old things in new ways, they may find themselves interacting with people they have not interacted with before, or interacting differently with people with whom they've often worked. Such changes in people's patterns of interaction, then, may prompt designers, developers, or others to develop new material features, thus highlighting the important role that social interaction plays in shaping the form and function of artifacts. For this reason, considering organizing as a process constituted through the reciprocal interplay of the material and the social may help to answer new questions about the nature of work.

By denying the distinction between technological and organizational change, the mutually constitutive approach makes it possible to finally drop the infamous "impact" metaphor. Researchers who have studied technology development and use from social constructivist perspectives, while diverse in their use of methodologies

and theoretical models, all cohere around the goal of showing that technologies do not ''impact'' social contexts in orderly ways. Instead, they argue that because technologies are developed at the confluence of social groups (Kline, 2003; Law, 1992; Pinch & Bijker, 1984) and enrolled in the political processes of interaction (Boudreau & Robey, 2005; Fulk, 1993; Markus, 1983), change is a process of gradual adjustment rather than one of decisive impact. However, by maintaining a distinction between technological and organizational change, even the most sensitive microsocial studies may unwittingly promote an impact metaphor when their analytic distinction between technology and organizing is reproduced at a macrosocial level of analysis. This is because when operationalizing technology and organizing as separate phenomena, authors of empirical studies must choose either a technology or an organization as a starting or stopping point. At a microsocial level of analysis, such choice is relatively unproblematic because, for example, if one chooses technology as a starting point and organization as an endpoint, he or she can easily trace back and forth between the two to show how the organization ''impacts'' the technology at Time 1, how the technology ''impacts'' the organization at Time 2, and so on (e.g., Barley, 1986; Orlikowski, 1992), thereby denying the suggestion of unilateral impact. However, when viewing change at a macrosocial level of analyses one is forced to abstract away from the recursiveness of impacts shown at a microsocial level and is left to conclude that with a ''technology'' starting point and an ''organizational'' endpoint, for example, that technology caused ''impacts'' in the organization. If, as the mutually constitutive approach suggests, technological and organizational changes are actually indistinguishable phenomena, the impact metaphor no longer holds. If no separation exists between technologies and organizations, no impact at any level of analysis can occur; indeed, ''impact'' is defined as the ''colliding of one thing against another,'' which presumes the existence of two separate things. Thus, a mutually constitutive approach may be one way of reconciling the mutually constitutive nature of technologies and organizations both at micro and macro levels of analysis.

In considering the second dichotomy—development-use—a mutually constitutive approach on technological and organizational change would allow researchers to move from talking about development and use as distinct *periods* in the lifecycle of a technology to conceptualizing them as *activities* that occur at various points in the process of organizing. The arguments put forth in this article suggest that the persistent tendency of social constructivist researchers to view development and use as distinct periods is one unintended consequence of the implementation line. A mutually constitutive approach that examines the interdependent relationship between technological and organizational change both diachronically and synchronically frees us from the temptation to construct artificial starting and stopping points, such as the implementation line, in the change lifecycle. In practice, activities of technology development often come before activities of implementation or use. Yet when conceptualizing how technologies and organizations mutually constitute one another it is of little theoretical use to link such activities to distinct periods because,

as Taylor (2001, p. 282) suggests, many organizational processes are ''crosstiled'' systems that have no definitive beginning or end points. Using the metaphor of a brick wall to describe the process of organizing, Taylor observes that it is possible to read the tiling of a wall as having either a left-handed or a right-handed sequence. In practice, a mason laid the wall from one side to the other, but as a wall, its functioning depends little on how its bricks were laid. As Taylor suggests, there is no ''right way to read the tiling strategy employed to construct the wall.'' Instead, Taylor argues that the way in which an analyst reads the tiling strategy ''reflects a cultural perspective imported by an interpreter.'' Similarly, we might conclude that social constructivist researchers, bringing cultural perspectives emerging from the specification of disciplinary and empirical boundaries, choose to impose an *a priori* division (amounting to an ordered distinction between development or use activities) on a cross-tiled structure that has no natural division. By employing a mutually constitutive approach, we can look past the temporal distinction between periods of development and use and instead focus our efforts on understanding how development and use manifest themselves as activities occurring simultaneously and recursively in the organizing process.

Early work by Rice and Rogers (Rice, 1987; Rice & Rogers, 1980; Rogers, 1995) and Lewis and Seibold (1993, 1996) planted the seeds for such thinking in their conceptualization of the reinvention process. These authors all drew on data from studies of process innovation implementations (e.g. dial-a-ride, job modification program) to suggest that consumers of a process do not always adopt that process in the exact way that managers or implementers intended. Rather, they often selectively implemented particular portions or modules of the process, changing some to fit their needs and ignoring others altogether. These early studies suggested that process innovation did not only happen in periods of development (e.g., the creation of the dial-a-ride process) but also during periods of use. However, through the use of concepts such as ''fidelity'' (Lewis & Seibold, 1993) and ''subversion'' (Rogers, 1995) these authors tended to reinforce an idea that there was a correct way to use an innovation, that the ''correct'' way was inscribed in the features of a technology during the *period of development*, and that the modifications made to the innovation during *periods of use* were somehow temporary and did not constitute a dramatic, influential, or lasting change in the form and function of the innovation under study.

By casting development and use as *activities* instead of *periods*, a mutually constitutive approach refrains from viewing changes that occur early in the technology-organizing lifecycle as either more or less correct or more or less important than changes occurring later. Instead, such an approach invites researchers to uncover what sorts of activities encourage redesign, whether certain types of technologies are more or less amenable to redesign and social construction throughout their lifecycles than others, and whether the structure of development activities restricts one's perceptions of the ranges of a given technology.

Conclusions

As the review and integrative framework presented in this article suggests, technological and organizational changes mutually constitute each other *within* development, implementation, and use activities (diachronically), as well as *across* them (synchronically). If researchers do not attempt to uncover how a technology occasions organizational changes until the technology is used they may miss seeing how organizational changes during the conduct of development activities enable the change of the technology itself. In other words, the mutually constitutive changes taking place within implementation activities, for example, may help to explain the contours of the changes that occur within use activities. As the perceptions held by actors, their appropriations, and their interaction patterns change to create a new sociocultural matrix in which the interaction of new groups now seems appropriate, negotiations take on new meanings, closure occurs for different reasons, and momentum of a particular technological design or use strategy is justified. Thus, if one looks only at development, implementation, or use activities in isolation from one another (diachronically), he or she will be unable to grasp fully those sociotechnical transformations surrounding the one set of activities that occasioned the interpretive conditions that influence the next set (synchronically).

Taken together, the points addressed above suggest that a framework that treats technological and organizational change as mutually constitutive must be attuned to how the process of organizing can lead to the creation and use of technologies that will change the process of organizing. As I have sketched it, this framework crosses the implementation line that has for many years inhibited a more complete social constructivist theory of the relationship between technological and organizational change. In so doing, it moves past the inadvertent tendency created by the gap between constructivist programs of research to view technological change as occurring only during a technology's development, and organizational changes occurring only during its use. Instead, it highlights the mutually constitutive relationship between technological and organizational change throughout the lifecycle of a technology—within and across the activities surrounding its development, implementation, and use.

When each social constructivist program is viewed alone, it is clear that the material and the social are inextricably intertwined. However, absent any explication of the relationship *between* the development and use of technology, even the most careful analyses will still treat technological and organizational changes as discontinuous events. If we are able to trace the organizational changes that brought about the particular form and function of that technology in the first place, we will then be able to more fully understand why certain technological changes lead to, or stymie, organizational transformation. To be useful, constructivist researchers of technological and organizational change should not arbitrarily end or begin their inquiry for reasons that are themselves socially constructed. Instead, a more complete understanding of the relationship between organizations and the technologies they

build and use will only be accrued once researchers begin crossing the implementation line.

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