Available online at www.sciencedirect.com
ScienceDirect
Information and Organization 18 (2008) 159–176
INFORMATION AND ORGANIZATION
www.elsevier.com/locate/infoandorg

Materiality and change: Challenges to building better theory about technology and organizing

Paul M. Leonardi [a,*], Stephen R. Barley [b]

[a] *Department of Communication Studies, Department of Industrial Engineering and Management Sciences, Northwestern University, 2240 Campus Drive, Evanston, IL 60208, United States*
[b] *Center for Work, Technology and Organization, Department of Management Science and Engineering, Stanford University, 422 Terman Engineering Center, Stanford, CA 94305, United States*

Received 8 October 2007; received in revised form 1 March 2008; accepted 10 March 2008

Abstract

Researchers have had difficulty accommodating materiality in voluntaristic theories of organizing. Although materiality surely shapes how people use technologies, materiality's role in organizational change remains under-theorized. We suggest that scholars have had difficulty grappling with materiality because they often conflate the distinction between the material and social with the distinction between determinism and voluntarism. We explain why such conflation is unnecessary and outline four challenges that researchers must address before they can reconcile the reality of materiality with the notion that outcomes of technological change are socially constructed.

1. Introduction

Building theory about the relationship between information technology and organizing sooner or later leads one to contemplate the line between the material and the social, a line that looks less solid up close than it does from a distance. Contemporary students of technology and organizations generally acknowledge the importance of both the material and the social, regardless of from which side of the distinction they begin or on which side they end up. For example, authors of research on information technology remind readers that

* Corresponding author.
E-mail addresses: Leonardi@northwestern.edu (P.M. Leonardi), Sbarley@stanford.edu (S.R. Barley).

1471-7727/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.infoandorg.2008.03.001

despite their materiality, technologies are products of negotiations (Constantinides & Barrett, 2006; Howcroft & Wilson, 2003; Orlikowski, 1992), human agency (Boudreau & Robey, 2005; Poole & DeSanctis, 2004; Vaast & Walsham, 2005) and personal interest (Kling, 1992; Markus & Benjamin, 1996; Scott & Wagner, 2003). Similarly, researchers acknowledge that organizing revolves around the interaction between people and machines (Mohr, 1971; Thompson & Bates, 1957), social and technical subsystems (Barley, 1990; Scott, 1998; Trist, 1981) or social and material practices (Orlikowski, 2002; Schatzki, 2005). In other words, there is general agreement that information technology and organizations both arise at the intersection of social and material phenomena. What remains unresolved, however, is the epistemological and ontological nature of the relationship between the material and the social and, hence, how information technologies and organizing are tied.

The difficulty of specifying the nature of this relationship often leads researchers to what Jackson, Poole, and Kuhn (2002) have called "the tendency to tilt". Although theorists may argue that social and material factors are equally important, most papers on the creation, perpetuation or change of technologies and organizations eventually favor one or the other. One reason for tilting may be our tendency to conflate two important, but separate, philosophical distinctions: the difference between determinism and voluntarism, on one hand, and the distinction between materialism and idealism, on the other (Barley, 1998). Determinism holds that our actions are caused by technological, cultural and other forces prior to, external to, and independent of our behavior. Voluntarism takes the opposite stance, arguing that humans have agency (what philosophers call "free will") and can shape their environments to achieve their interests and goals. To be a materialist is to hold that human action stems from physical causes and contexts such as geography, biology, climate, and technology. Conversely, idealists argue that ideas, norms, values, ideologies and beliefs (what most of us call the social) drive human action.

Although the distinction between determinism and voluntarism is orthogonal to the distinction between materialism and idealism, social scientists frequently write as if materialism implies determinism and idealism implies voluntarism. This is simply not the case.[1] To be sure, early work on information systems adopted a materialist stance and favored deterministic explanations for technologically-induced organizational change (Leavitt & Whistler, 1958; Mann & Williams, 1960; Swanson, 1974). It is also true that researchers have worked hard to counter the legacy of materialistic determinism by showing that users' practices, beliefs and agendas significantly shape how information technologies affect organizing and that agency matters even when it is unwitting (Holstrom & Robey, 2005; Orlikowski, 2000; Poole & DeSanctis, 2004; Walsham, 2002). Authors of such studies often explicitly or implicitly criticize materialist accounts for promoting determinism and instead champion a perspective that is both more idealistic and more voluntarist (Boczkowski, 2004; Boudreau & Robey, 2005; Constantinides & Barrett, 2006; Schultze & Orlikowski, 2004).

Yet neither materialistic determinism nor voluntaristic idealism exhausts the universe of viable visions of technology and organizing. For example, it is possible to be an idealist and a determinist, as was Braverman (1974), who argued that technological deskilling

[1] See Barley, 1998 for a discussion of materialistic determinism, idealistic determinism, materialistic voluntarism and idealistic voluntarism and for illustrations of how to classify theories of technology according to this four-fold typology.

was the *inevitable* outcome of a dominant managerial ideology that stressed the separation of conception from execution. Conversely, one can also be a materialist and a voluntarist, as are most ergonomists, who believe that technologies directly shape human behavior but that because technologies are designed and because designs can be altered, humans can both intend and change the social effects of a technology by redesigning it or, failing that, by refusing to use it.

The problems with conflating determinism with materialism, on one hand, and voluntarism (agency) with idealism (or the social) on the other are twofold. First, tilting to either social or material explanations of change too often becomes value-laden. Those who emphasize the material antecedents of technological or organizational change are often accused of being determinists and, hence, blind to the role that people play in bringing about technologies' effects on organizing. Conversely, those who privilege social antecedents are chided for ignoring materiality and for being too quick to deny an artifact's demonstrable constraints and affordances. Over time, such stances acquire a kind of moral authority that warrants programs of research that marginalize and even eschew alternative explanations of empirical findings. This leads to the second and ultimately more important problem: theoretical accounts that are epistemologically and ontologically unable to handle the entwining of the material and the social and that cannot speak with precision about degrees of agency and constraint.

Our agenda in this paper is to move toward reconciling materialism with voluntaristic (or agential) theories of change. Materiality matters for theories of technology and organizing because the material properties of artifacts are precisely those tangible resources that provide people with the ability to do old things in new ways and to do things they could not do before. The materiality of information technology remains grossly under-theorized (Orlikowski & Iacono, 2001; Zamutto, Griffith, Majchrzak, Dougherty, & Faraj, 2007), in large part, because conflating materialism with determinism poses subsidiary challenges that make it difficult to tease apart the role of the material and the social.

In this paper we outline four such challenges. The first challenge is simply to recognize that it is possible to talk about a technology's materiality without also being a determinist. The second challenge is to broaden the range of technologies that contemporary researchers normally choose to study. The third is for researchers to study the relationship between development and use in order to understand how the practices of designers effect users and vice versa. The final challenge is for researchers to realize that they no longer need to demonstrate that technologies can occasion different outcomes in different social contexts. We have reached the point where more can be gained by asking why different organizations experience similar outcomes with the same technology. In outlining these four challenges our goal is to push research in directions that will stimulate new ways of understanding the dynamics of technologically-induced change and enable scholars to build better theory about the role of materiality in the process of organizing.

2. Four challenges for theory building

2.1. Acknowledging materiality's relevance

Technological determinism entered organization studies with the work of early contingency theorists. Having discovered that differences in type of production systems explained considerable variance in her data on the structure of British manufacturing firms, Woodward (1958, p. 16) claimed that "different technologies imposed different kinds of demands on individuals and organizations, and that these demands had to be met through an appropriate organization form". Perrow (1967, p. 195) advocated a similar perspective in his classic study of US hospitals where he penned the well-cited dictum: "technology is an independent variable, and structure... a dependent variable".[2] Yet, it is important to recognize that contingency theorists meant something quite different by "technology" than what most contemporary students of technology and organization have in mind when they use the term.

Woodward (1958, p. 16) defined technology as a "system of techniques", while Perrow (1967, p. 194) saw it as the "work done in organizations". In general, contingency theorists equated technology with what industrial engineers would call a production system, which is comprised of people, processes, and machines, all of which must be coordinated to transform inputs into outputs. Contingency theorists never concerned themselves with specific artifacts (like hardware or software) or artifacts' identifiable material properties. Instead, writers such as Woodward (1965), Thompson (1967), Perrow (1970) and the Aston group (Hickson, Pugh, & Pheysey, 1969; Pugh, Hickson, Hinings, Turner, & Lupton, 1963) examined the interdependences in work processes that organizations had to manage when running one type of production system, say small batch manufacturing, rather than another, such as continuous process. In fact, Aldrich (1972, pp. 28–29) took the Aston studies to task early on for defining technology so broadly (i.e. "work flow integration") that their measures could only assess whether an organization was in the manufacturing or service sector.

In contrast, contemporary students of information technology and organizing typically define their object of study more narrowly, precisely, and concretely. Rather than operationalize technology as a constellation of techniques, processes, and work practices, researchers today mostly study identifiable *artifacts* such as email systems, groupware technologies, and enterprise resource planning (ERP) systems. As Orlikowski (2000, p. 408) suggests, a technological artifact is a "bundle of material and symbol properties packaged in some socially recognizable form, e.g., hardware, software". Because most information technologies are software rather than solid physical objects, it may seem odd to say that information technologies have "material properties". But, when material properties are construed as features that provide opportunities for or constraints on action, the metaphor seems warranted.

The important point is that information technology, or for that matter any artifact, has materiality in a concrete sense that production systems and "work flow integration" do not. For sure, systems of production do involve material artifacts and these certainly have material properties, but systems of production are also social systems. It was for this reason that Marxists spoke of production systems as having two components, forces and relations of production, and that socio-technical systems theorists talked about the entwining of the social and the technical system. Indeed, the genius of early socio-technical systems theory was to show that the same forces of production (technology) could actually support different social arrangements (Emery, 1959; Rice, 1953; Trist & Bamforth, 1951). Contin-

[2] Perrow (1983, 1986) long ago broke away from this perspective as can be easily gleaned by reading his work on control rooms, normal accidents and human factors. Although he retains an appreciation for the implications of a technology's materiality, he no longer links materiality and determinism. In his latter work, humans shape both technologies and organization structures.

gency theorists never got close enough to the artifacts of production to examine whether they posed material constraints on organizing. What contingency theorists did was call some aspects of a production system, "technology", and other aspects of the production system "organizational structure", and then seek correlations between the two. What was technology and structure varied from author to author (see Barley, 1988; Orlikowski & Barley, 2001 for further discussion).

Organizational theorists continue to overlook the substantial difference between what contingency theorists and contemporary researchers meant by the term, by technology. Consequently, they use contingency theory's vision of a deterministic relationship between technology and organizing at a macro-level of analysis as a foil for voluntaristic findings, which usually entail evidence of variation in use at a much lower level of analysis. A study showing that people use a technology in ways other than designers or managers intended appears more surprising when initially framed against contingency theory's more deterministic stance. This rhetorical ploy may have been useful when Barley (1986) and others urged organizational scholars to take a more voluntaristic stance, but the cost has been to perpetuate an inappropriate comparison between studies that examine radically different phenomena.

As Orlikowski and Barley (2001, p. 148) point out, the problem with contingency theory, media richness theory and other theories that attempt "to reduce technology to an abstract material cause in the name of generalizability", is not so much the notion of materiality as the desire to leap quickly to broad, law-like claims. In short, the problem is determinism not materialism. Because of materialism's and determinism's juxtaposition in contingency theory, social constructionists tended to jettison both simultaneously. Hence, those who might claim that the material properties of a technology can influence the organization of work risk being labeled "determinists", a term that has become something of a slur in academia (see, for example, Winner, 1998).

Perhaps because materialism has acquired the stigma of determinism, students of technology and organizing generally pay little analytic attention to a technology's material constraints and affordances and focus, instead, on showing how people organize around the technologies they employ. As a result, attention gravitates to the social: to interactions, interpretations, behaviors and so on (e.g. Barley, 1986; Fulk, 1993; Orlikowski, 1992, 2000; Robey & Sahay, 1996). Even the most influential studies of organizations and information systems focus primarily on social dynamics or on how people interact with each other around the technology, rather than providing evidence of what specific material features people use, why they use them, and how and why their patterns of use shift over time.

Sociologists of science have shown that attending to agency and social dynamics is not incompatible with an appreciation for material constraints and affordances (Latour & Woolgar, 1986; Lynch, 1985). Like research on technology and organizing, the sociology of science turned toward social construction in the 1980s. The turn led some researchers to favor explanations of change that privileged social over material practices (Knorr-Cetina & Mulkay, 1983; Woolgar, 1988). Eventually, however, scholars began to caution that such an orientation may be misguided because material phenomena (be they natural or technical) do things that cannot be attributed to social practice (Fujimura, 2006; Hutchby, 2001; Pickering, 2001). Pickering (1995) argues persuasively that physical phenomena resist scientists' efforts to manipulate them and that this resistance is, in fact, part of the conversation between scientist and object that leads scientists to alter their methods and their theories. Technologies also resist, in the sense that they do not allow users to do whatever they want. However, the fact that technologies resist does not mean that users are at the mercy of the technology, only that they must adapt their practices accordingly.

To integrate materiality with a more voluntaristic stance requires that researchers attend directly to the specific ways in which the features of particular artifacts become entangled in the social practices of people's work (Clarke & Fujimura, 1992; Knorr-Cetina, 1999; Pickering, 1995). In addition to studying social dynamics such as perception and interpretation, this means paying attention to what a technology lets users do, what it does not let them do, and to the workarounds that they develop to address the latter. In technology studies, students of computer-supported cooperative work whose work is rooted in ethnomethodology and activity theory have made the most progress on this score (e.g. Blomberg, Suchman, & Trigg, 1996; Heath & Luff, 2000; Nardi & Engeström, 1999).

2.2. *Developing typologies of constraints and affordances*

The majority of empirical studies undertaken by organizational, information systems, and communications researchers focus on the ways that people use information technologies to communicate or store data (see for review Leidner & Kayworth, 2006; Rice & Gattiker, 2001). For example, researchers often study how people use cell phones (Arnold, 2003; Leonardi, 2003), personal digital assistants (PDAs) (Schlosser, 2002), email (Fulk, 1993; Markus, 1994), group decision support systems (GDSSs) (Alavi, Marakas, & Yoo, 2002; DeSanctis & Poole, 1994; Scott, Quinn, Timmerman, & Garrett, 1998), collaborative authoring tools (Majchrzak, Rice, Malhotra, King, & Ba, 2000; Orlikowski & Gash, 1994) and other information technologies as conduits for sending messages. Additionally, there are many studies showing how information technologies such as knowledge management systems (Leonardi, 2007a; Schultze & Boland, 2000), version control systems (Dufner, Kwon, & Rogers, 2001), customer relationship management (CRM) systems (Koh, Ang, & Straub, 2004; Romano & Fjermestad, 2003) and ERP systems (Boudreau & Robey, 2005; Markus, Axline, Petrie, & Tanis, 2000) are used to store and disseminate codified knowledge to a broad audience.

Leonardi and Bailey (2008) have recently argued that many information technologies do more than simply transmit or store information, they also can transform one type of information into other types of information that can be acquired by no other means. Finite element analysis (FEA) tools that allow engineers to simulate automobile crashes are a case in point. Through a series of complex algorithms FEA tools combine data from CAD drawings with vectors of data on velocity, the elasticity of steel and host of other conditions to produce within several hours a three-dimensional visualization of how the body of a specific vehicle responds when it crashes into a stationary object. FEA also produces a dataset that allows engineers to track how energy moves through the vehicle's body moment-by-moment. In principle, an army of engineers with unlimited time and money might be able to produce a comparable dataset, but doing so would take years. Regardless of resources and time, they could have never produced visualizations without FEA. Before FEA automobile engineers, therefore, never undertook such complex calculations. Instead, they relied solely on retrospective and less precise data generated by instruments attached to an automobile during a physical test. They had to crash cars into walls and observe what happened.

Technologies that produce new forms of information that enable people to do things that they could not have otherwise done are becoming increasingly common across the professions. For example, simulation technologies are increasingly used in professions as diverse as medicine (Streufert 2001), finance (Staum, 2001) and architecture (Boland, Lyytinen, & Yoo, 2007), as well as in engineering. Geographical information systems (GIS) combine data on topography, water flow, weather and a host of other variables to create integrated maps that enable geologists, foresters and members of other occupations to visualize complex patterns of interaction among spatially distributed data (Robey & Sahay, 1996; Walsham & Sahay, 1999). Computerized medical imaging technologies such as ultrasound and computed tomography enable radiologists to see and diagnose pathology that could not be visualized using standard X-rays (Barley 1990). Technologies that combine and transform data have even created new opportunities in manufacturing settings (Vallas, 2001; Zuboff, 1988).

Whereas communication and storage technologies provide material capabilities that allow people to do things that they did not do before because doing so cost too much or was too inefficient (for example, having a team distributed across two or more continents), technologies that transform information not only offer affordances that change work practices; they often change the nature of the work itself. When technologies are used in ways that allow people to do new things that would have been impossible before, tasks and roles frequently change. When work roles change, role relationships usually change: workers interact with colleagues in new ways and may even find themselves interacting with members of occupations with whom they formerly had no contact. When role relationships change, it is likely that the social network that defines the structure of an organization will also shift.

Leonardi (2008) documented precisely such a cascading pattern of change in the field of crashworthiness engineering in the automobile industry. Until the early 1980s crash testing involved two occupations: design engineers, who developed a vehicle's architecture, and proving ground technicians, who crashed real cars into a variety of stationary and moving obstacles to test how their architecture withstood the force of an impact. Beginning in the late 1980s, FEA tools came into common use in automotive engineering. Because FEA required knowledge and skills that neither design engineers nor technicians possessed, by the mid-1990s a new occupation, performance engineering, emerged. Performance engineers specialized in using FEA to predict crash dynamics. At first, these engineers mediated the relationship between design engineers and test technicians. But, as FEA tools become more refined and the information they created became more complex and accurate, performance engineers began to predict the results of crash tests reliably, thus reducing the need to conduct expensive and time consuming physical crashes. As a result performance engineering became increasingly central in the vehicle development process, while design engineers lost status and power.

During this same period of time, automotive engineering also began to make extensive use of computer-mediated communication tools, advanced databases and online repositories. Although these technologies enabled automobile manufacturers to modularize and distribute crashworthiness activities across the globe, unlike FEA they did not alter the fundamental nature of crashworthiness engineering. Instead, these tools allowed the reproduction of existing practices and the replication of existing role relationships and power dynamics in new locations. In short, how the various technologies affected the practice and organization of crashworthiness work was tied to the technologies' materiality and the nature of affordances that the materiality provided. Whereas communication and storage technologies altered how crashworthiness engineers practiced, FEA changed what they practiced and as a consequence the very definition of what it means to be a crashworthiness engineer.

An interesting implication of such differences is that we might better predict the nature and extent of technologically occasioned organizational change by developing a language for talking about classes of constraints and affordances. One hypothesis might be that technologies that produce novel forms of information will have broader implications for the nature and organization of work than will technologies that primarily enable people to do current tasks in more efficient or effective ways. At present we have no language for making clear distinctions between types of constraints and affordances, in part, because we have paid little attention to technologies' material properties and, in part, because we have examined a relatively small set of information technologies. Developing viable typologies of material constraints and affordances requires a broader comparative range. Specifically, we need to extend our purview beyond the communication tools and sophisticated databases that have attracted so much attention in recent years. The agenda would be to capture variation in socio-material configurations and opportunities for change. Since the mid-1980s students of technology and organizing have relied heavily on research designs that compare the use of identical or similar technologies in different contexts to highlight the role that social dynamics play shaping a technology's effects. At this point, we are likely to learn more about materiality by adopting the opposite approach: comparing radically different technologies in the same or similar contexts.

2.3. Bridging activities of development and use

With a few notable exceptions (Leonardi, 2007b; Orlikowski, 1996; Thomas, 1994), students of technology have developed a division of labor by specializing in what happens either before or after a technology is introduced into a work setting. Those who have studied information technology and organizing have historically concerned themselves with what happens to organizations and to users during and after implementation (e.g. Barley, 1990; Black, Carlile, & Repenning, 2004; Fulk & Boyd, 1991; Karahanna, Straub, & Chervany, 1999; Lewis, Agarwal, & Sambamurthy, 2003; Markus & Benjamin, 1996; Orlikowski, 1996; Zack & McKenney, 1995). Conversely, sociologists who write about the social construction of technology (SCOT) have, until very recently, specialized in studying the development and design of technologies (see Oudshoorn & Pinch, 2003 for exceptions).

However, useful this division of labor may be for ensuring that programs of research can be accomplished in an acceptable time frame, by separating developers from users we have placed serious limitations on our collective ability to unravel the relationship between agency, the material, and the social. The disjuncture between our knowledge of the social dynamics of a technology's development and our understanding of the social dynamics of its use, prompts us to treat as if true, conditions that we know are false. We know, for instance, that the development of a technology does not necessarily cease after users encounter it. Not only is feedback from users often critical for developers who design later versions of a technology (von Hippel, 1988), but users may in some circumstances modify the technology themselves (Johnson & Rice, 1987; Rice & Rogers, 1980). Yet, when we end investigations of development once developers have closed on a design, we cannot speak to how use affects redesign. We also know that technologies are already social products when they arrive on the scene. But when we begin studies of use at the time of implementation, we *de facto* treat the technology that arrives as a black box because we usually do not know what its prior social history may have been and, hence, why it arrives with its particular constellation of features.

Failure to bridge development and use makes it difficult to speak to several of technology studies most pressing questions. For example, do developers intend their technologies to shape either the work practices of users or the structures of organizations in particular ways and, if so, how do designers embody their intentions in designs? Do such designs subsequently have the effects that designers intended? If so, why? If not, why not? Orlikowski (1996) is one the few researchers who have bridged development and use. In the process of studying an incident tracking system deployed by a technical services group, Orlikowski was not only able to interview the system's designers and implementers but to follow users' work practices as they emerged over a two year period. She found that designers did have images of how technical specialists should work and that they did structure the technology with the goal of achieving their agenda. But the pattern of use that evolved was only partiality what the designers envisioned. As users' practices and agendas changed, they commissioned modifications of the technology to support their new ways of working. Like Orlikowski, a number of other researchers have begun to argue that when misalignments surface between the functionality of an existing technology and users' needs, people often physically adapt the technologies with which they work (Majchrzak et al., 2000; Markus, 2004; Pollock, 2005; Tyre & Orlikowski, 1994).

Studying ongoing cycles of design, use and modification or what Orlikowski (1996) called "metamorphoses" provides a strong strategy for untangling the relationship between agency, the material and the social because it can treat both the social and material as emerging, evolving, and entwined. Contemporary students of technology and organization generally appreciate that organizing around the use of a technology is an ongoing, emergent activity shaped by previous ways of doing things, the properties of the technology itself, political and social dynamics, and improvisation in the face of the task at hand. Drawing on the history of hand tools, barbed wire, and the steam engine, Basalla (1988), a historian of technology, argues convincingly that few, if any, technologies arise de novo and that even fewer cease to change once they enter contexts of use. Instead, most artifacts are changed over time to meet the evolving demands of those who use them. From this perspective the question is not whether technologies change through use, but rather, what processes lead to change and what determines the pace at which change occurs.

Studying the interplay between materiality and agency across development, implementation and use will require modifications in typical research strategies. To date, most students of technology and organizing follow the social: that is, even though they may select research sites based on their interest in a particular technology, data collection typically involves charting patterns of use, interaction and organizing. When studying the co-evolution of the material and the social, it may make more sense to follow the technology. One can conceptualize the material biography of a technology not only as a trajectory in time, but as movement within and between a number of social settings and groups. As Leonardi's (2007b) study of the development and use of a modeling tool by performance engineers demonstrates, tools move through the social worlds of a variety of different groups as they evolve. In Leonardi's case, these groups included research and development engineers, design engineers, implementers, engineering management and a variety of vendors. As the technology moved from one group to another, each altered the technology's material properties in light of its own agenda and perspective.

Because studying the co-evolution of the material and social requires longitudinal data, and because different technologies evolve at a different pace, researchers may need to select the technologies they study and modify their research designs to make such studies feasible. For instance, all else being equal, we would expect that it would be easier to pursue co-evolutionary research on technologies that are both developed and used within the same organization. Typically, such technologies are designed with specific users in mind, the users have recourse to designers and decision makers and, hence, cycles of use and redesign may be shorter and more tightly linked. Mass marketed technologies, like word processing programs, spreadsheets and CAD software, pose more of a challenge for studying co-evolution of the material and the social. Designers capable of significantly altering such technologies are usually distant from the people who use them. Moreover, because people use mass technologies for a multitude of purposes and in a multitude of contexts, their experiences may generate many versions of what Orlikowski (2000) calls technologies-in-use. Studying the co-evolution of the material and the social in the case of mass technologies may, therefore, require many years of investigation, and researchers are likely to have difficulty determining which users and which types of use have affected the technology's redesign.

In between lie what we might call modifiable, off-the-shelf technologies such as manufacturing resource planning (MRP), CRM, ERP, and other similar systems. In such cases, an organization typically purchases a core technology and then employs either in-house developers or vendors to modify the technology for the organization's specific use. Because the developers and users of modifiable, off-the-shelf technologies tend to be closely tied, cycles of feedback between use and redesign should occur relatively quickly and be relatively easy to trace. When the developers and users of such technologies are located in different organizations, researchers may even be able to track how changes in one organization affect changes in another.

2.4. Shifting to studies of constructionism

Most researchers who reject determinism for a more voluntaristic stance on technology and organizing would argue that technologically occasioned change is a social construction. Yet "social construction" is a broad term covering a number of different, but related social processes (Pinch, 1996, p. 18). How one conceptualizes social construction significantly shapes the phenomena to which one attends and, by extension, the type of theoretical account that one is likely to offer. The prominence of certain conceptions of social construction may partially explain why materiality has played a less prominent role than it might otherwise play in more voluntaristic research on technology and organizing. To see why this might be, Papert's (1991, p. 1) distinction between social construct*ivism* and social construct*ionism* is useful:

> The word with the v [constructivism] expresses the theory that knowledge is built by the learner, not supplied by the teacher. The word with the n [constructionism] expresses the further idea that this happens felicitously when the learner is engaged in the construction of something external or at least shareable...a sand castle, a machine, a computer program, a book.

Papert uses constructi*vism* to refer to the cognitive processes by which people construct unique understandings and interpretations of the world. Construct*ionism,* on the other hand, involves communicative acts in which multiple people, through their interaction with one another, make the world in common. Constructivism highlights subjectivity, while constructionism concerns the intersubjective. Pearce (1995, p. 98) elaborates: “If neither term is taken as excluding the other, constructivists foreground perception while social constructionists foreground action”. Note that the distinction is not about how many people are involved in developing the construal or whether the process is social. Both are equally social. Rather, the distinction is about what social processes underwrite construal. As Gergen (2001, p. 60) puts it, social constructivism is “a mental process…significantly informed by influences from social relationships” while social constructionism emphasizes that interaction in social relationships is “the vehicle through which self and world are articulated”.

Constructivism recognizes that each person (if persons are the unit of analysis) or organization (if organizations are the units of analysis) faces local contingencies that encourage situated improvisations, which ultimately lead to a unique constellation of practices and understandings. Constructionism holds that a set of people or organizations eventually construct and share similar realities that they take-for-granted as natural, efficacious, and necessary. When applied to studies of information technology, the distinction promotes asking different questions about technological change. Construc*tivists* ask, “Why do similar organizations experience different outcomes with the same technology?” Construct*ionists* ask, “Why do different organizations experience similar outcomes with the same technology?”

The former question seems predicated on challenging the determinist assumption that information technologies should engender similar outcomes across organizations. The latter seems to take path dependency and situated outcomes as the natural state of affairs and asks why, then, does adopting an information technology sometimes led to similar outcomes in different organizations. Most advocates of “social construction” in studies of information systems and organizing have worked as constructivists seeking to answer the first question. Consider the following statements drawn from three influential studies published in each of the last three decades:

> If nothing else, the foregoing analysis demonstrates that by treating technology as an occasion for structuring, researchers will confront contradictory results head-on because of structuring’s central paradox: identical technologies can occasion similar dynamics and yet lead to different structural outcomes… In short, structuring theory holds that technical uncertainty and complexity are social constructions that vary from setting to setting even when identical technologies are deployed. (Barley, 1986, pp. 105–106)
>
> The results obtained reaffirm the value of an interpretive approach to research on technological change in organizations by showing how nearly identical technologies occasioned quite different social meanings and consequences in comparable organizational settings. This study contributes to the general argument that information technologies are socially constructed… (Robey & Sahay, 1996, p. 108)
>
> The technology was, of course, identical at both hospitals. The framing and social construction of the technology was vastly different. Two distinct technological frames emerged: MICS as a plug-in component and MICS as a team innovation project. These frames were held by leaders and communicated to others in subtle ways and seemed to matter greatly in how team members construed the technology and, more importantly, their role in making it work for patients and for the organization. (Edmondson, Bohmer, & Pisano, 2001, p. 708)

The authors of each study highlighted how and why identical technologies ''occasioned'' divergent outcomes across multiple organizations. Jackson et al. (2002) and Rice and Gattiker (2001) have shown that the same logic underwrites most other empirical studies of the social construction of technologically-induced organizational change. Given that voluntarist images of technologically-induced organizational change are now reasonably well accepted, we submit that additional constructivist studies will at best bring modest empirical or theoretical advance. More progress might be made by shifting research to a constructionist agenda.

To do so, researchers would start by assuming (1) that the outcomes of adopting an information technology will reflect unique social processes that transpire in the immediate context of the technology's use, (2) that information technologies and an organization's social structure merge in idiosyncratic ways, and (3) that people often use technologies in ways other than managers or designers intend. The central research problem could then become: Given these conditions, how is it possible that that a new technology often occasions remarkably similar changes in practice and organizing across settings? In other words, in the absence of deterministic materialism and in the face of agency, how can we account for consistency of use and relatively uniform outcomes?

Orlikowski (2000, p. 421) suggests that such questions fall well within the purview of studies of practice:

> While a practice lens recognizes that technology use is always situated and emergent, it does not imply that such use is completely unique. On the contrary, because regular use of the same technology tends to be recurrent, people tend to enact the same or similar technologies-in-practice over time. In this way, enacted technology structures become routine, taken for granted, and even institutionalized within certain circumstances.

Orlikowski's insight is that asking the constructionist question would lead researchers to attend to institutionalization, legitimation and taken-for-grantedness, processes that neo-institutional organizational theorists have long argued are responsible for the observed homogeneity of organizational forms and practices (DiMaggio & Powell, 1983, 1991; Meyer & Rowan, 1977; Scott, 1995).[3] Two general lines of argument for homogeneity of socio-material practices across settings that do not resort to deterministic materialism seem promising.

The first would be to consider the kinds of social processes that have been well documented by neo-institutionalists, albeit largely outside the domain of socio-technical change. These include the spread of practices via social networks, the influence of consultants, trainers and other professionals, and the role of the media in conferring legitimacy. That similar social processes might operate to induce homogeneity of technological practice seems reasonable. For example, we know that when organizations consider adopting relatively costly and complex technologies they frequently send representatives to visit organizations where the technology has already been implemented to see what others have done (Thomas, 1994). Organizations also frequently employ consultants and trainers to teach employees how to use technologies just prior to or concomitant with bringing the

[3] Interestingly enough, the early neo-institutionalists were also rebelling against the same contingency theories that early constructionist students of technology challenged and for much the same reason: materialistic determinism left inadequate room for agency.

technologies on line (Barley, 1984; Leonardi, 2007b). To the degree that trainers and consultants teach standard practices and offer the same point of view each time they present, they are likely to be a force for homogeneity of both perception and practice. Finally, it is plausible that firms that write documentation and the media that specialize in providing technology advice play a role in legitimizing some forms of practice rather than others.

A second line of argument would look to the material constraints and affordances of the technology itself. Although it seems reasonably clear that technologies do not dictate general practices or forms of organizing, it is nevertheless the case that a technology's materiality does set constraints on and offer affordances for use. It is worth entertaining the idea that key constraints and affordances sometime push practice in one direction rather than another, if for no other reason than an alternative practice is too difficult or costly.

Although the notion of key constraints or affordances may be difficult to anticipate a priori, they may be more easily identified in context. For example, Barley (1990) argued that the need to use information currently displayed on a computer monitor to make decisions about what to do next during an ultrasound procedure created pressure on radiologists to grant sonographers autonomy and to encourage them to become proficient at interpreting sonograms. Although doing so radically altered institutionalized role relationships between radiologists and technologists, radiologists typically accepted the change because doing otherwise would have required radiologists to perform every exam themselves. That sonographers generally possess more diagnostic knowledge and enjoy greater autonomy than do most other technologists in almost all hospitals 20 years later illustrates how the materiality of a technology can shape practice consistently without determining it.

3. Conclusion

Our goal in this paper has been to examine challenges that confront researchers who study and theorize about the nature of technologically-induced organizational change. Since the late 1970s and early 1980s when micro-computers made the use of information technologies commonplace, students of information systems and organizations have sought to understand the role that artifacts play in organizing work. Partially because scholars have spent nearly 30 years battling the tenants of technological determinism, the role of materiality in organizational change remains understudied (Orlikowski, 2007; Suchman, 2007). We have argued that researchers have had difficulty incorporating the role of materiality into their studies because they have wittingly or unwittingly conflated determinism with the material and voluntarism with the social. In the process they have inadvertently created a number of hurdles for themselves that have made it difficult to reconcile notions of materiality with theories of change that highlight agency. We outlined four such challenges and have suggested how researchers might overcome them without resorting to determinism.

All of our suggestions rest on assembling accurate depictions of the way people work. Today, individuals in a wide variety of occupations and organizations routinely interact not only with people but with information technologies. The latter indisputably have material properties. Although those material properties result from choices made by particular groups of designers, they confront users with real constraints on and opportunities for conducting their work. Understanding how people deal with an information technology's materiality seems essential for developing a broader and fuller understanding of organizing. By bringing materiality more centrally into theories of change we should be able to speak more precisely about why people do the things they do with technology and why organizations and practices acquire the forms they acquire.

Acknowledgement

The authors wish to thank Wanda Orlikowski and Dan Robey for alerting us to shortcomings in earlier versions of this manuscript and for suggesting ways to overcome them. We take responsibility for all remaining problems.

References

Alavi, M., Marakas, G. M., & Yoo, Y. (2002). A comparative study of distributed learning environments on learning outcomes. *Information Systems Research, 13*(4), 404.

Aldrich, H. E. (1972). Technology and organizational structure: A reexamination of the findings of the Aston group. *Administrative Science Quarterly, 17*(1), 26–43.

Arnold, M. (2003). On the phenomenology of technology: The Janus-faces of mobile phones. *Information and Organization, 13*(4), 231–256.

Barley, S. R. (1984). *The professional, the semi-professional and the machine: The social implications of computer-based imaging in radiology*. Unpublished doctoral dissertation, Massachusetts Institute of Technology.

Barley, S. R. (1986). Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments. *Administrative Science Quarterly, 31*(1), 78–108.

Barley, S. R. (1988). Technology, power, and the social organization of work: Towards a pragmatic theory of skilling and deskilling. *Research in the Sociology of Organizations, 6*, 33–80.

Barley, S. R. (1990). The alignment of technology and structure through roles and networks. *Administrative Science Quarterly, 35*(1), 61–103.

Barley, S. R. (1998). What can we learn from the history of technology?. *Journal of Engineering and Technology Management 15*, 237–255.

Basalla, G. (1988). *The evolution of technology*. Cambridge: Cambridge University Press.

Black, L. J., Carlile, P. R., & Repenning, N. R. (2004). A dynamic theory of expertise and occupational boundaries in new technology implementation: Building on Barley's study of CT scanning. *Administrative Science Quarterly, 49*, 572–607.

Blomberg, J., Suchman, L., & Trigg, R. H. (1996). Reflections on a work-oriented design project. *Human–Computer Interactions, 11*(3), 237–265.

Boczkowski, P. J. (2004). The processes of adopting multimedia and interactivity in three online newsrooms. *Journal of Communication, 54*(2), 197–213.

Boland, R. J., Lyytinen, K., & Yoo, Y. (2007). Wakes of innovation in project networks: The case of digital 3-D representations in architecture, engineering, and construction. *Organization Science, 18*(4), 631–647.

Boudreau, M.-C., & Robey, D. (2005). Enacting integrated information technology: A human agency perspective. *Organization Science, 16*(1), 3–18.

Braverman, H. (1974). *Labor and monopoly capital: The degradation of work in the twentieth century*. New York: Monthly Review Books.

Clarke, A., & Fujimura, J. (Eds.). (1992). *The right tools for the job: At work in twentieth century life sciences.* Princeton: Princeton University Press.

Constantinides, P., & Barrett, M. (2006). Negotiating ICT development and use: The case of telemedicine system in the healthcare region of Crete. *Information and Organization, 16*, 27–55.

DeSanctis, G., & Poole, M. S. (1994). Capturing the complexity in advanced technology use: Adaptive structuration theory. *Organization Science, 5*(2), 121–147.

DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review, 48*, 147–160.

DiMaggio, P. J., & Powell, W. W. (1991). Introduction. In W. W. Powell & P. J. DiMaggio (Eds.), *The new institutionalism in organizational analysis* (pp. 1–38). Chicago: University of Chicago Press.

Dufner, D., Kwon, O., & Rogers, W. (2001). Enriching asynchronous learning networks through the provision of virtual collaborative learning spaces: A research pilot. In *Proceedings of the 34th Hawaii international conference on system sciences* (pp. 1004–1013).

Edmondson, A. C., Bohmer, R. M., & Pisano, G. P. (2001). Disrupted routines: Team learning and new technology implementation in hospitals. *Administrative Science Quarterly, 46*(4), 685–716.

Emery, F. (1959). *Characteristics of sociotechnical systems*. London: Tavistock Institute.

Fujimura, J. H. (2006). Sex genes: A critical sociomaterial approach to the politics and molecular genetics of sex determination. *Signs: Journal of Women in Culture and Society, 32*(1), 49–82.

Fulk, J. (1993). Social construction of communication technology. *Academy of Management Journal, 36*(5), 921–951.

Fulk, J., & Boyd, B. (1991). Emerging theories of communication in organizations. *Journal of Management, 17*(2), 407–447.

Gergen, K. J. (2001). *An invitation to social construction*. London: Sage.

Heath, C., & Luff, P. (2000). *Technology in action*. Cambridge, England: University Press.

Hickson, D. J., Pugh, D. S., & Pheysey, D. C. (1969). Operations technology and organizational structure: An empirical reappraisal. *Administrative Science Quarterly, 14*(3), 378–397.

Holstrom, J., & Robey, D. (2005). Inscribing organizational change with information technology. In B. Czarniawka & T. Hernes (Eds.), *Actor-network theory and organizing* (pp. 165–187). Malmo: Liber.

Howcroft, D., & Wilson, M. (2003). Paradoxes of participatory practices: The Janus role of the systems developer. *Information and Organization, 13*(1), 1–24.

Hutchby, I. (2001). Technologies, texts and affordances. *Sociology, 35*(2), 441–456.

Jackson, M. H., Poole, M. S., & Kuhn, T. (2002). The social construction of technology in studies of the workplace. In L. A. Lievrouw & S. Livingstone (Eds.), *Handbook of new media: Social shaping and consequences of ICTs* (pp. 236–253). London: Sage.

Johnson, B., & Rice, R. E. (1987). *Managing organizational innovation*. New York: Columbia University Press.

Karahanna, E., Straub, D. W., & Chervany, N. L. (1999). Information technology adoption across time: A cross-sectional comparison of pre-adoption and post-adoption beliefs. *MIS Quarterly, 23*(2), 183–213.

Kling, R. (1992). Audiences, narratives and human values in social studies of technology. *Science Technology and Human Values, 17*(3), 349–365.

Knorr-Cetina, K. D., & Mulkay, M. (Eds.). (1983). *Emerging principles in social studies of science*. London: Sage.

Knorr-Cetina, K. (1999). *Epistemic cultures: How the sciences make knowledge*. Cambridge, MA: Harvard University Press.

Koh, C., Ang, S., & Straub, D. W. (2004). IT outsourcing success: A psychological contract perspective. *Information Systems Research, 15*(4), 356.

Latour, B., & Woolgar, S. (1986). *Laboratory life: The construction of scientific facts*. Beverly Hills, CA: Sage.

Leavitt, H. J., & Whistler, T. L. (1958). Management in the 1980s. *Harvard Business Review, 36*(6), 41–48.

Leidner, D. E., & Kayworth, T. (2006). A review of culture in information systems research: Toward a theory of information technology cultural conflict. *MIS Quarterly, 30*(2), 357–399.

Leonardi, P. M. (2003). Problematizing "new media": Culturally based perceptions of cell phones, computers, and the Internet among United States Latinos. *Critical Studies in Media Communication, 20*(2), 160–179.

Leonardi, P. M. (2007a). Activating the informational capabilities of information technology for organizational change. *Organization Science, 18*(5), 813–831.

Leonardi, P. M. (2007b). *Organizing technology: Toward a theory of socio-material imbrication*. Unpublished Doctoral Dissertation, Stanford University.

Leonardi, P. M. (2008). *Co-evolution of technological, regulatory and organizational innovations in the automotive safety movement: Exploring the transformation of logics*. Working Paper, Department of Communication Studies, Northwestern University.

Leonardi, P. M., & Bailey, D. E. (2008). Transformational technologies and the creation of New Work practices: Making implicit knowledge explicit in task-based offshoring. *MIS Quarterly, 32*(2).

Lewis, W., Agarwal, R., & Sambamurthy, V. (2003). Sources of influence on beliefs about information technology use: An empirical study of knowledge workers. *MIS Quarterly, 27*(4), 657–678.

Lynch, M. (1985). *Art and artifact in laboratory science: A study of shop talk in a Research Laboratory*. London: Sage.

Majchrzak, A., Rice, R. E., Malhotra, A., King, N., & Ba, S. L. (2000). Technology adaptation: The case of a computer-supported inter-organizational virtual team. *MIS Quarterly, 24*(4), 569–600.

Mann, F. C., & Williams, L. K. (1960). Observations on the dynamics of a change to electronic data-processing equipment. *Administrative Science Quarterly, 5*(2), 217–256.

Markus, M. L. (1994). Electronic mail as the medium of managerial choice. *Organization Science, 5*(4), 502–527.

Markus, M. L. (2004). Technochange management: Using IT to drive organizational change. *Journal of Information Technology, 19*, 4–20.

Markus, M. L., Axline, S., Petrie, D., & Tanis, C. (2000). Learning from adopters' experiences with ERP: Problems encountered and success achieved. *Journal of Information Technology, 15*, 245–265.

Markus, M. L., & Benjamin, R. I. (1996). Change agentry – The next IS frontier. *MIS Quarterly, 20*(4), 385–407.

Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American Journal of Sociology, 83*(2), 340–363.

Mohr, L. (1971). Organizational technology and organizational structure. *Administrative Science Quarterly, 16*, 444–459.

Nardi, B. A., & Engeström, Y. (1999). A web on the wind: The structure of invisible work. *Computer Supported Cooperative Work, 8*, 1–8.

Orlikowski, W. J. (1992). The duality of technology: Rethinking the concept of technology in organizations. *Organization Science, 3*(3), 398–427.

Orlikowski, W. J. (1996). Improvising organizational transformation over time: A situated change perspective. *Information Systems Research, 7*(1), 63–92.

Orlikowski, W. J. (2000). Using technology and constituting structures: A practice lens for studying technology in organizations. *Organization Science, 11*(4), 404–428.

Orlikowski, W. J. (2002). Knowing in practice: Enacting a collective capability in distributed organizing. *Organization Science, 13*(3), 249–273.

Orlikowski, W. J. (2007). Sociomaterial practices: Exploring technology at work. *Organization Studies, 28*(9), 1435–1448.

Orlikowski, W. J., & Barley, S. R. (2001). Technology and institutions: What information systems research and organization studies can learn from each other. *MIS Quarterly, 25*, 145–165.

Orlikowski, W. J., & Gash, D. C. (1994). Technological frames: Making sense of information technology in organizations. *ACM Transactions on Information Systems, 12*, 174–207.

Orlikowski, W. J., & Iacono, C. S. (2001). Research commentary: Desperately seeking the "IT" in IT research – A call to theorizing the IT artifact. *Information Systems Research, 12*(2), 121–134.

Oudshoorn, N., & Pinch, T. (Eds.). (2003). *How users matter: The co-construction of users and technology*. Cambridge, MA: MIT Press.

Papert, S. (1991). Situating constructionism. In I. Harel & S. Papert (Eds.), *Constructionism* (pp. 1–12). Norwood, NJ: Ablex Publishing.

Pearce, W. B. (1995). A sailing guide for social constructionists. In W. Leeds-Hurwitz (Ed.), *Social approaches to communication* (pp. 88–113). New York: The Guilford Press.

Perrow, C. (1967). A framework for the comparative analysis of organizations. *American Sociological Review, 32*, 194–208.

Perrow, C. (1970). *Organizational analysis: A sociological view*. Belmont, CA: Wadsworth.

Perrow, C. (1983). The organizational context of human factors engineering. *Administrative Science Quarterly, 28*, 521–541.

Perrow, C. (1986). *Complex organizations: A critical essay* (3rd ed.). New York: Random House.

Pickering, A. (1995). *The mangle of practice: Time agency and science*. Chicago: University of Chicago Press.

Pickering, A. (2001). Practice and posthumanism: Social theory and a history of agency. In T. R. Schatzki, K. Knorr-Cetina, & E. vonSavigny (Eds.), *The practice turn in contemporary theory* (pp. 163–174). London: Routledge.

Pinch, T. J. (1996). The social construction of technology: A review. In R. Fox (Ed.), *Technological change: Methods and themes in the history of technology* (pp. 17–35). Amsterdam: Harwood.

Pollock, N. (2005). When is a work-around? Conflict and negotiation in computer systems development. *Science Technology and Human Values, 30*(4), 496–514.

Poole, M. S., & DeSanctis, G. (2004). Structuration theory in information systems research: Methods and controversies. In M. E. Whitman & A. B. Woszczynski (Eds.), *Handbook of information systems research* (pp. 206–249). Hershey, PA: Idea Group.

Pugh, D. S., Hickson, D. J., Hinings, C. R., Turner, C., & Lupton, T. (1963). A conceptual scheme for organizational analysis. *Administrative Science Quarterly, 8*, 289–315.

Rice, A. K. (1953). Productivity and social organization in an Indian weaving shed: An examination of some aspects of the socio-technical system of an experimental automatic loom shed. *Human Relations, 6*(4), 297–329.
Rice, R. E., & Gattiker, U. (2001). New media and organizational structuring. In F. M. Jablin & L. L. Putnam (Eds.), *The new handbook of organizational communication: Advances in theory, research, and methods* (pp. 544–581). Thousand Oaks, CA: Sage.
Rice, R. E., & Rogers, E. M. (1980). Reinvention in the innovation process. *Knowledge, 1*, 499–514.
Robey, D., & Sahay, S. (1996). Transforming work through information technology: A comparative case study of geographic information systems in county government. *Information Systems Research, 7*(1), 93–110.
Romano, N. C. J., & Fjermestad, J. (2003). Electronic commerce customer relationship management: A research agenda. *Information Technology and Management, 4*, 233–258.
Schatzki, T. R. (2005). The sites of organizations. *Organization Studies, 26*(3), 465–484.
Schlosser, F. K. (2002). So, how do people really use their handheld devices? An interactive study of wireless technology use. *Journal of Organizational Behavior, 23*, 401–423.
Schultze, U., & Boland, R. J. (2000). Knowledge management technology and the reproduction of knowledge work practices. *Journal of Strategic Information Systems, 9*(2–3), 193–212.
Schultze, U., & Orlikowski, W. J. (2004). A practice perspective on technology-mediated network relations: The use of Internet-based self-serve technologies. *Information Systems Research, 15*(1), 87–106.
Scott, W. R. (1995). *Institutions and organizations*. Thousand Oaks, CA: Sage.
Scott, W. R. (1998). *Organizations: Rational natural and open systems* (4th ed.). Upper Saddle River, NJ: Prentice Hall.
Scott, C. R., Quinn, L., Timmerman, C. E., & Garrett, D. M. (1998). Ironic uses of group communication technology: Evidence from meeting transcripts and interviews with group decision support system users. *Communication Quarterly, 46*(3), 353–374.
Scott, S. V., & Wagner, E. L. (2003). Networks, negotiations and new times: The implementation of enterprise resource planning into an academic administration. *Information and Organization, 13*(4), 285–313.
Staum, J. (2001). Simulation in financial engineering. In *Proceedings of the 2001 winter simulation conference* (pp. 123–133).
Streufert, S. (2001). Improving medical care: The use of simulation technology. *Simulation and Gaming, 32*(2), 164–174.
Suchman, L. (2007). *Human–machine reconfigurations: Plans and situated actions*. Cambridge: Cambridge University Press.
Swanson, E. (1974). Management information systems: Appreciation and involvement. *Management Science, 21*(2), 178–188.
Thomas, R. J. (1994). *What machines cannot do: Politics and technology in the industrial enterprise*. Berkeley: University of California Press.
Thompson, J. D. (1967). *Organizations in action: Social science bases of administrative theory*. New York: McGraw-Hill.
Thompson, J. D., & Bates, F. L. (1957). Technology, organization, and administration. *Administrative Science Quarterly, 2*(3), 325–343.
Trist, E. L. (1981). The sociotechnical perspective: The evolution of sociotechnical systems as a conceptual framework and as an action research program. In A. H. Van De Ven & W. F. Joyce (Eds.), *Perspectives on organization design and behavior* (pp. 19–75). New York: John Wiley & Sons.
Trist, E. L., & Bamforth, K. W. (1951). Some social and psychological consequences of the longwall method of coal-getting. *Human Relations, 4*(1), 3–38.
Tyre, M. J., & Orlikowski, W. J. (1994). Windows of opportunity: Temporal patterns of technological adaptation in organizations. *Organization Science, 5*(1), 98–118.
Vaast, E., & Walsham, G. (2005). Representations and actions: The transformation of work practices with IT use. *Information and Organization, 15*, 65–89.
Vallas, S. P. (2001). Symbolic boundaries and the new division of labor: Engineers, workers and the restructuring of factory life. *Research in Social Stratification and Mobility, 18*, 3–37.
von Hippel, E. (1988). *The sources of innovation*. New York: Oxford University Press.
Walsham, G. (2002). Cross-cultural software production and use: A structuration analysis. *MIS Quarterly, 26*(4), 359–380.
Walsham, G., & Sahay, S. (1999). GIS for district level administrators in India: Problems and opportunities. *MIS Quarterly, 23*(1), 38–66.

Winner, L. (1998). Prophets of inevitability. *MIT's Technology Review, 101*(2), 62.
Woodward, J. (1958). *Management and technology*. London: HSMO.
Woodward, J. (1965). *Industrial organization*. London: Oxford University Press.
Woolgar, S. (Ed.). (1988). *Knowledge and reflexivity: New frontiers in the sociology of knowledge*. London: Sage.
Zack, M. H., & McKenney, J. L. (1995). Social context and interaction in ongoing computer-supported management groups. *Organization Science, 6*(4), 394–422.
Zamutto, R. G., Griffith, T. L., Majchrzak, A., Dougherty, D. J., & Faraj, S. (2007). Information technology and the changing fabric of organization. *Organization Science, 18*(5), 749–762.
Zuboff, S. (1988). *In the age of the smart machine: The future of work and power*. New York: Basic Books.