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The Computerization of Work: A Social Informatics Perspective*

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In this chapter we focus on the computerization of work. We do so because work continues to be a powerful lens for understanding both organizations and society. What we do for work helps to shape, and is also shaped by, the nature and structure of civil society, local community, the organization of industry and government, family relations; and personal identity. That is, and paraphrasing Karl Marx, the means of production (working) help to structure society. To support and enable work we have developed a range of social institutions, corporate organizations, and a wide (and ever-growing) range of computer-based systems. These computer systems include applications such as word processing and office suites, groupware, integrated software development environments, mobile infrastructures, and enterprise systems, to name a few. As we develop in this chapter, the increasing level of computerization (by which we mean the pervasiveness and importance of computer-based systems) in work may be helpful but is often problematic.

Why is it that office workers will use electronic mail extensively but show little interest in systems that control and regulate work flow? Why do organizational leaders face resistance when trying to implement automated production controls? Why are many potentially productivity-enhancing systems used at lower than expected levels once implemented? We write this chapter with the intent that our findings can provide insights into these and similar questions. The findings we report here regarding the computerization of work that can be used to guide information systems and work-process designers, organizational decision makers, and other scholars in their research.

To help understand current, and guide future, computerization of work efforts, we make two points. First, we make the case that a social informatics perspective provides an excellent conceptual frame from which to view the computerization of work. A social

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informatics perspective focuses on the social and organizational consequences of using computers. Such a perspective is problem oriented and contextually relevant, viewing work as it occurs. This approach typically highlights unexpected and unintended effects. Second, within this frame we highlight the added insights possible due to taking a functional view of computing. A functional view of computing is one focused on understanding how computers are used. This is often done by studying specific groups of people in specific settings, here represented by reporting on three specific types of work.

To best make our points we organize this chapter into four sections. In the first section we discuss the concepts of work and computerization and provide evidence on the increasing level of computerization in work. In the second section we build on these concepts and more fully develop the social informatics perspective as a framework for understanding the computerization of work. And, in doing this, we also develop our functional conceptualization of computer use. In section three we explain our selection of, and summarize results from, studies of three different forms of work: packaged (vendor) software developers, organizational technologists, and residential real estate agents. In section four we present and discuss three broad findings that our work highlights: (1) functional insights of computerization, (2) the omnipresence of articulation work (the work done to ensure the computer does what is needed or expected), and (3) ongoing power shifts, due in part to computerization, in the workplace.

The numbers of people using computers at work continue to grow, as the numbers in Table 1 help make clear. The increasing degree of convergence among computing and communicating systems, evidenced by the merging of cable and computing networks, the rise of mobile networks, and the increasing ability to transmit larger files due to greater bandwidth, underlie this growth in computer use at work. Moreover, the range of computing devices being used is expanding so that the concept of computer time (the time spent in front of a computer terminal) is ever more appropriately seen as "screen time" (the time spent in front of some form of computing device whether it is with a workstation, mobile phone, personal digital assistant, medical diagnostic system, etc.). For example, doctors use computers in the conduct of diagnosis, to scan medical literature, to track patient records, to communicate with others by phone, and perhaps even to play downloaded music on MP3 players while in the operating room. Car mechanics do the same, though they play their music in a different form of 'operating room.'

These two examples make clear what the 1999 National Research Council (NRC) report on the *Changing Nature of Work* says in detail: The computerization of work can be described in a number of ways. Here we use a three-part division of work and computerization: as directly involved with using computers, as indirectly involved with using computers, and as not using computers (see Table 1). Direct users of computers can further be seen as comprising two forms of computerization. One form of direct users of computers in work are those workers who design, develop, install, operate,

TABLE 1 The Computerization of Work in the United State*

Type	*2000*	*1990*	*1980*	*1970*
Direct: IT sector	4.1	3.5	2.5	1.2
Direct: ← Users	10.3	8.2	4.1	1.4
Indirect users	69.1	57.7	12.4	7.3
Total number	110.9	102.7	95.8	80.1

*Numbers in millions and approximate.
Sources: NRC, 1999; OECD, 2001; Kling, 1990.

train, and support computers, computer-based applications, and other forms of information technology (IT). This work is often called the "IT sector." (note 1)

A second form of direct users of computers consists of those workers who use computers in their everyday work. Examples of this form of work computerization include: small business owners running their own accounting and customer tracking software, use of sophisticated diagnostic systems by mechanics in vehicle repair, and real estate agents' extensive use of linked mobile communications and Web-based systems (such as the multiple listing service, or MLS). These workers may be direct users of computer-based systems, but only to support primarily noncomputing elements of their work. The number of less 'sophisticated' direct users is also large and increasing. For example, point-of-sale (POS) systems in retail stores are a form of what might be called tertiary computerization. The person (which is increasingly becoming the customer) who is scanning items through the POS terminal is engaged in computerized work, albeit primarily doing data collection. This segment of the population, increasingly seen as the engine of the economy, represents many professional and technical workers such as doctors, engineers, and scientists (Barley 1996; Barley and Kunda 2001; Kling 1990).

Beyond these two forms of directly computerized workers are indirect users of computers at work. Indirect users include many service workers whose work schedules, task allocation, and work monitoring are computerized (via automated scheduling and work tracking systems). For example, many hourly workers are required to clock in and out of their jobs, and this tracking is increasingly done via software, and the records are digitized. Indirect users have traditionally been an underreported and understudied area of computerization, primarily because most studies of computerization focus on high-status primary and secondary users (Clement 1994). However, recent changes to workforce contexts (at least in the use) due to legal and policy changes (such as changes to welfare policies, pressure on immigration polices such as H1-B visa quotas, and globalization pressures) are likely to spur increased attention to this form of work and the effects on it from computerization. Estimates of the number of people who are indirect users of computers at work are obviously difficult to make. The issue, however, is that even nonusers (and we imply that larger numbers of these nonusers) are being affected by computerization of work processes, of which their non-computer-using work is part.

Computing-based work is also expanding. U.S. Bureau of Labor Statistics (2002) data indicate that occupations that rely on using computers are projected to be the fastest growing types of work, with employment expected to have double-digit percentage increases between 2000 and 2010. Working with computers is often lucrative, especially for direct users of computers. Simply, future job opportunities will be excellent for most workers who use computers. Professional and administrative workers enjoy the best future work prospects. This is due in part to a continuing demand for higher (and broader) level skills needed to keep up with changes in computer-based technologies.

This high-level evidence makes clear that the computerization of work is extensive, expanding, and highly valued. And, as Zuboff (1988) made clear, the uses of computing are changing the structural properties of work; mediating workers from the work via sensors used to collect (and make digital) data; the ability to transmit, store, and manipulate data; and the increased expectation that this digitization and decision support is part of all work. Increased automation is the engine behind the steady and extensive productivity improvements in manufacturing, the means to deliver services and products in financial and other knowledge-based industries, and a growing form of automating service work. While simplistic, the computerization of work has been an important basis for the growth of the postindustrial, knowledge-based economy that Porat and others have foretold (e.g., Porat 1977; Bell 1976). More detailed analyses make clear that the computerization of work is a complex, large-scale phenomena (Benner 2002).

Work

Work's pervasiveness helps to mask the conceptual difficulties of explaining what it means. In this chapter we characterize work as the set of roles that a worker enacts and the tasks they are charged to do. This characterization raises the roles of agency and governance, suggesting that an individual's work must be understood relative to what others are doing. McGrath and colleagues note that this perspective implies that a person's social needs and ego status are also tied to the production elements of work (McGrath 1990; McGrath and Hollingshead 1994). In doing this, they make clear that work is more than agency and governance, it is also identity and socialization (Hackman and Oldham 1980; Hackman 1977).

In this chapter we focus on a specific type of working where the worker's knowledge needs (skill, experience; and education) is a much greater component of their effort than is manual labor (heads-in, not hands-on focus). We do so because this so-called knowledge-intensive work is increasingly the focus of computerization efforts. Knowledge work further is often characterized by the increased level of interdependence (among tasks, resources and people) and the temporal nature of these interdependencies. Further, knowledge-intensive work is often characterized by abstractions such as what is embodied in production processes that guide worker's tasks and actions. This process abstraction further elevates the issues of work governance because it requires both worker and supervisor to use abstractions. That is, it is difficult to "see" a partially complete software program, so it often described via abstractions such as modules, features, and lines of code.

The issues with control of knowledge, importance of interdependencies, and the required abstractions about work processes means that governance is a contested space in knowledge-intensive work because knowledge disparities often lead to power disparities (White 1981). More generally, the governance of work has always been a contested space (as the rise of industrial engineering, industrial relations, professional management, and federal mediation forums indicate). So, knowledge-intensive work is also a forum for the negotiation (and perhaps transfer) of social power among different types of workers (Zuboff 1988; Kling and Iacono 1984, 2001; Clement 1994; Barley and Kunda 2001).

Computerization of Work

Computerization of work efforts are extensive and ongoing, as we noted earlier, but the effects of computerization are less clear. Often, computerization efforts are conceived as directly affecting work, primarily as a means to either replace labor or increase througput and quality. Scholars have noted that this simple view of computerizing work is problematic (Attewell 1996, 1998; Roach 1998; Landauer 1996; Kling 1996; Kling and Dunlop 1995).

Computerization of work efforts are typically undertaken for one or more of the following reasons: The first is to use computer-based systems to enable the conduct of current tasks. This is often done by substituting use of computer-based systems for manual processes. The second is to link, and often speed-up, the conduct of work tasks and processes. This is often done through using rules, decision aids, and other representations to assist workers in their tasks. The third is to use it as a means (or platform) to leverage future operations (Ciborra 1996). This platform argument is often phrased as a means for investing in future capabilities. Beyond these high-level goals there is also the continued effort to upgrade, connect, and even repair current systems. This effort may also support other work goals, but often is done to continue allowing for current operations (such as upgrading office suite software to maintain compatibility with other applications).

A Social Informatics Perspective

Social informatics is the large, diverse, and growing body of research and study that examines social and organizational aspects of computerization, such as the roles of computers in social and organizational change and the ways that the uses of computers are influenced by social and organizational structures and actions (Kling 1999; Sawyer and Eschenfelder 2002; Kling, Sawyer, and Rosenbaum 2003). Social informatics is not a theory or a method. Social informatics provides a set of empirically grounded orienting principles that makes explicit particular elements of the socio-technical perspective regarding developing, deploying, and using computers.

Three broad findings that arise from the empirical basis of social informatics research help focus our attention on work and computerization. The first finding is that computers are embedded in, and also help to shape, the context of their use. For example, Ward, Wamsley, Schroeder, and Robins (2000) investigate the assumption that computerization promotes autonomy, organizational change, and greater responsiveness. Their analysis of computing implementations and uses at the U.S. Federal Emergency Management Administration (FEMA) helps to show how existing control structures within the agency shape budgeting for computers. The resulting systems reinforce existing power structures in the organization. They explain that the Reagan Bush administration's emphasis on national security led to the allocation of most FEMA computing resources to civilian defense-related projects and the location of the agency information resources management office to be in the civilian defense division. This allocation process left other parts of the agency, including the disaster planning division, suffering for lack of computing resources and unable to deal effectively with major U.S. natural disasters such as Hurricane Hugo, Hurricane Andrew, or the Loma Prieta earthquake. They conclude that government investment in computing does not automatically produce greater responsiveness, as the larger social context shapes the programs in which the computer systems are procured, implemented, and used.

The second common finding drawn from social informatics research is the often paradoxical and unintended effects of computerization. These effects typically vary by both level of analysis and the ways in which computers are used. For example, Adams and Sasse (1999) studied the work practices and environments that contribute to improper use of passwords. Their findings challenge the idea that organizations can achieve greater system security through use of strict security regulations such as periodic forced password changes, multiple unique passwords for different systems, and requirements for non-dictionary-word-based passwords. They suggest that more strenuous security measures may in fact decrease overall security. In explaining their thesis, they describe both contextual and cognitive factors leading to password misuse. For instance, they explain how certain types of work tasks encourage group sharing of passwords, for example, if a workgroup is sharing access to a particular set of files. In these instances, the security mechanisms interfered with the group-based nature of their work. That is, required use of individual passwords interfered with the work done by the employees. The study suggests that security applications developers and departments need to improve their understanding of work practices in order to develop applications and processes that comport with work practices.

In a second example of the paradoxical and unintended consequences of computerization, Walsham (1998) reports how the use of groupware, ostensibly designed to improve communication, may actually harm group interactions. Participating pharmaceutical sales representatives reported that the software did help to achieve one of the intended goals: Use lessened the need for face-to-face communications as certain interactions could be done electronically. Through analysis of the social context surrounding the system, Walsham also reports that reduction in face-to-face time harmed overall group communication by removing opportunities for social networking and relationship building.

The third common finding drawn from social informatics research is that computers and computer-based systems are not neutral artifacts: There is agency in their design and, due to their configurational nature, there is agency in their use. For example, Kraut, Dumais, and Koch (1989) highlight the ways in which computerization of phone operators was designed to reduce the number of human operators, limit the work autonomy of the remaining operators, increase managerial control, and increase throughput (of answered calls). Clement and Halonen (1998) show how computerization efforts can advantage one group over another. They examine how user groups and information systems specialists in a large utility company differed in their conceptualizations of a "good" system and good systems development practice. According to Clement and Halonen, for the users, a good system was customized for different offices such that use required minimum knowledge of office-specific codes. Good development practice required code customization for each office, resulting in the existence of multiple unique versions of the software and a great deal of ad hoc programming. From the information systems perspective, good systems development practice required standardization, version control, and minimal code changes. This approach led to the creation of a less user-friendly system that required more enduser expertise. Clement and Halonen's study also showcases the ways in which different conceptualizations of a good system, and good systems development practices, benefit one group more than another. User groups favored the ad hoc, customized development practices because they resulted in a more flexible, customizable, user-friendly system. The information systems group preferred a more structured, systematized approach to development because it resulted in a more easily manageable software product.

Conceptualizing Computerization

Conceptualizing the connections among doing work and using computers requires a more detailed depiction of computing than is often developed in direct effects models (Kling and Lamb 2000). Direct effects models of computing (and even models of mediating effects) characterize computers as endogenous to their setting of use (MacKenzie 1992). That is, the computer is seen as an external force, perhaps as an agent of change, and the features of this tool are easily understood (both in terms of use and outcomes). This tool view suggests that a computer-based system need not be connected to the scenes of its use (Orlikowski and Iacono 2001). This further suggests a form of stable meaning for a computer: Tools do not change over time, unless these changes are designed into new forms of the tool (such as additional features in new releases of software). The implied stability of meaning inherent in a tool view tends to minimize the changing nature of tool use due to the context of its use.

Alternatively, computers can be seen as they are used: embedded into particular and specific social milieu (Mackenzie 1992; Orlikowski and Iacono 2001; Jackson, Poole, and Kuhn 2002). This social constructivist view suggests that the meaning, value, and ascribed outcomes of computer use are developed in relation to how they function in particular situations and not to the set of features that they designed to support (Jackson, Poole, and Kuhn 2002). This functional perspective suggests that computers are part of a web of meaning that includes the current understanding of both the computer's and people's roles, the rules and norms of use, and the larger work context and incentive structures in which all of these are developed (Taylor 1982, 1986; Kling and Scacchi 1982). This functional view of computerization leads observers and scholars to making explicit the connections (interdependencies) among computer-based systems and the elements of work described previously. (note 2)

A functional conceptualization of computing leads to viewing computing as supporting (1) communication and coordination, (2) access to information, (3) production support, (4) controlling and monitoring, and/or (5) entertainment. That is, computer-based systems can enable people to communicate and coordinate more (and often more easily) with one another (and even with other things like sensors). Computers can function to provide for greater (and perhaps easier) access to data (where access can mean search, retrieval, storage, and manipulation of data). Computers can function to enhance production efforts, such as the use of business rules, automated processing, information processing, and other forms of information processing and computation. People can also use computers to assist them in controlling and monitoring (from mundane things such as password protection to the use of sophisticated sensor networks to monitor people's movements). And, though not often considered in work settings, computers can be used for entertainment and enjoyment. This can range from making pleasing interfaces to the sharing of music and playing online and individual gaming on or via computers. Clearly, combinations of these functions are possible (if not certain). That is, the control, production, coordination, and access functions are all enabled by the interdependent systems and common data structures inherent in enterprise systems (e.g., Markus, Axline, Petrie, and Tanis 2000; Markus and Tanis 2000).

Three Studies of Work

We use the three findings of social informatics as a means to frame the analysis of our empirical studies of work and computerization. As a basis for discussing these findings, we first review the empirical work from studies of packaged software developers, organizational technologists, and residential real estate agents. The conceptual rationale for focusing on these occupations is two-part, as we outline below and summarize in Table 2. First, each represents a distinct form of knowledge work. Second, each group of workers were (and are) using forms of computerization that were (and are) considered important to the ways in which their work will be done. (note 3)

Packaged Software Developers

Our first source of evidence on computerization of work comes from 10 years studying packaged software developers (See Sawyer and Guinan 1998; Sawyer and Carmel 1998; Sawyer 2001a, 2001b, 2000). We focused on software developers because their work requires a high level of abstraction and knowledge about the domain of development, development methods and tools, and group and team processes. We specifically focused our studies of work on developers who made products to sell to the open market (as opposed to internal or sole-source customers), which we call packaged software developers. Examples of packaged software are Peoplesoft, DB2, Word, and Autocad. The rewriting of IRS tax code software is not done by packaged software workers.

Because software is often lauded as the United State's (and perhaps the world's) largest source of innovation (even after the failure of many "dot-com" companies at the end of the twentieth century), we sought to better understand the roles of computerization in packaged software development. We focused on two computerization efforts relative to packaged software developers. The first computerization effort was the push in the early 1990s to use a range of computer-aided software engineering (CASE) tools (Guinan, Cooprider, and Sawyer 1997). (note 4) The second computerization effort, and partially a response to issues with CASE use, was the emphasis on supporting developer coordination needs using e-mail and common access to work

TABLE 2 Forms of Knowledge Work and Computerization

Type of Work	*Knowledge Aspects*	*Computerization Aspects*
Packaged software developers	Design abstractions Design methods and tools Group and team processes	Computer-aided Software Engineering (CASE) tool suites Collaborative computing spaces
Organizational technologists	Work process abstractions Requirements elicitation Project and change management Group and team processes	Enterprise Integration (EI) software Work flow and database components Client/server and distributed computing
Residential real estate agents	Work process abstractions Professional norms and rules Home and community data Professional networks	Multiple listing service (MLS) and Web tools to search the MLS Integrated mobile and land-line telephony and personal digital assistants

products and the use of collaborative rooms to support development (e.g., Sawyer, Farber, and Spillers 1997).

Packaged software developers work for organizations whose primary function is to make software for sale to others via markets (as opposed to internal customers or direct contractual arrangements). With the potential for huge rewards, packaged software development work reflects many attributes of the entrepreneurial legend: individualistic orientation, long work hours, determination, and a willingness to take on risk. Packaged software development organizations are designed around highly individualistic work practices. Rugged individuals—software cowboys—are respected, even revered, in most packaged software organizations. The individualistic, rule-abhorring developer is not as attractive to most traditional (internal-to-an organization) software development departments who typically seek process-oriented workers.

Packaged software firms function in an environment of intense time-to-market pressure relative to IS development efforts. This is due, in part, to packaged software being such a high-profile industry today under continual scrutiny by investors, stockholders, Wall Street analysts, and hundreds of technology media sources. Success is typically measured by profits and revenues, market share, and good product reviews in trade journal and trade shows (such as COMDEX). Most traditional development efforts are measured by user satisfaction, user acceptance, quality, and cost. Developers in packaged software firms are in "line" positions, whereas the in-house software developers are in "staff" positions. In packaged software shops, developers are the primary producers of revenue for the company. Thus, developer needs are central to production.

To support developer individualism and product innovation needs, in packaged software development the product itself is the focal point and the process with its engineering orientation, is both secondary and less mature. For example most packaged software firms rely on software development guidelines or templates, not strict development methods. Software product teams tend to be small, loosely controlled in terms of work, though product design is often carefully controlled by two or three "core" team members. Teams tend to be product loyal over time and exhibit high cohesion among members.

Organizational Technologists

Our second source of evidence on the computerization of work is drawn from 6 years studying organizational information technologists (see Eschenfelder, Heckman, and Sawyer 1998; Sawyer and Southwick 2002; Sawyer 2001b). By organizational technologists, we mean the information systems staff of an organization. This includes the programmers, network administrators, database specialists, systems analysts, trainers, end-user support staff, technical management, and consultants and contractors used to support the organization's computing infrastructures, systems, and applications. These people work inside larger organizations to support the development, implementation, operations, and support users of the organization's computing infrastructures.

We studied organizational technologists because, in the late 1990s, their work began shifting from developing, maintaining, and operating internally constructed systems to that of enabling the acquisition, implementation, and operations of vendor-developed enterprise resource planning (ERP) systems (Markus and Tannis 2000). The computerization of work efforts included both the changes to the technologists' work (and their work focus) and the ways that these systems change the work of those who were to use these integrated production and control systems.

The changes to organizational technologists' work increased their need to understand work processes at an abstract level and to focus less on technical operations and more on user requirements and the ways in which the ERP systems would enable user needs. This change increased the need for organizational technologists to lead and manage project (and organizational) change and to work with vendors, consultants, and the line workers. The technical change to organizational technologists' work has been just as dramatic. They have had to learn how to work with new technologies such as distributed and client/server computing (instead of mainframes), software packages (instead of software languages), and integrated applications based on work flow and database connectivity (instead of stand-alone modules).

The basis of ERP is an integrated set of application modules connected to a common database. These modules provide partial automation support for business processes (such as ordering, finance, payroll-HR, product process flow, etc.). The common database allows for improved worker and managerial control, amplifies the focus on (production) processes, and improves access to data. Improved coordination and communication are not the intent of ERP. However, the process orientation and level of effort needed to implement such large systems demands extensive collaboration and communication (Sawyer and Southwick 2002).

In the organizations that we studied, the central information technology group promoted extensive user involvement, often leading to the forming of dozens, if not hundreds, of user/technologist committees to assist in implementing the new distributed computing systems. Most of these committees were led by line, not technology, people. A second aspect of the decentralization of the technologists was the creation of a distributed technical staff program. Distributed technical staff serve as network managers, troubleshooters, trainers, and local computer "gurus" (Eschenfelder, Heckman, and Sawyer 1998).

ERP system implementations are typically conceived as a multiproject effort. The order and priority of these projects is defined by negotiating among key stakeholders such as senior line managers, technology vendors, executive leaders, and internal technologists. The criteria that helped to structure these negotiations included user/functional needs, availability of needed software, political gain, and resources. Selecting a vendor-provided software (the ERP) forced the organizational technologists to shift their focus from mainframe to client/server computing and comprehend the new, interdependent, enterprisewide modules and data architectures.

Organizational technologists' work has been affected in at least two ways: (1) how workers view the tasks they do and (2) how they interact with others. Workers' tasks, for example, are more interdependent, have higher levels of visibility, greater variety, less autonomy in selection (i.e., often they must respond to what others have done), and demand a broader variety of skills to complete. This is a difficult adjustment for many because they had become familiar with the relative simplicity (and monochronicity) of supporting a stable (mainframe) technology.

Technologists are also responsible for more tasks. Because the tasks demand new ways of sequencing and are more interconnected, workers are having to participate in more task sharing, where many people contribute to completing one task. Thus, the worker's day is often more fragmented as they constantly connect with others to complete these shared tasks.

Residential Real Estate Agents

Our third source of evidence about the computerization of work is drawn from 4 years studying residential real estate agents (Crowston, Sawyer, and Wigand 2001; Sawyer, Crowston, Wigand, and Allbritton 2003). We focused on this form of work for several reasons. The work of residential real estate agents is information intensive, based on a distributed and emergent work process, has unique contractual structures such as agency relationship among agents, brokers, local agencies and national franchises, and is undergoing rapid computerization.

The rapid computerization is reflected in changes to the technologies of access, coordination, and production. For example, relative to production, in the late 1990s much of the information contained in their databases of houses (known as the multiple listing service, or MLS) was made available on the Web. This effort also centralized access to the MLS data as MLS franchises are local, but common access is done through a common Web portal and sophisticated query and tracking tools to search and monitor the MLS. At the same time, rapid improvements in mobile phone technologies allowed agents to integrate land-line phones (and voice mail) with their mobile phones to link these to electronic lists of buyers and sellers, and to manage all of this with little technical support (or specific technical know-how).

Residential real estate agents' work is transaction based and is bounded by a set of legal and regulatory codes. It is focused on moving information around and relies on the agent's ability to keep track of an abstract and very contingent process that requires extensive coordination of a range of people. Agents serve as intermediaries between buyers and sellers of houses, bringing both information and process (the sale of a house is culminated in its "closing," though the actual steps in the closing process are contingent on a range of factors).

The role of real estate agents is to bring together the seller and buyer of a property and to advise both of these principals, independently, regarding their responsibilities in the transaction. In the United States two agents are typically involved in a transaction. The listing (or seller's) agent assists a seller in marketing a property by helping to determine an asking price, guiding the seller to make the property attractive, advertising it, and screening potential buyers. When offers to buy the property are received, the seller's agent advises the seller in the negotiations and details of the transaction. The second (typically known as the buyer's) agent helps a buyer find suitable properties among those offered for sale and narrow the selection to a specific property. The buyer's agent advises the buyer on the purchase. Thus, the typical house sale/purchase has the buyer and seller negotiating with the intermediation of the buyer's agent and the seller's agent.

In most cases, the seller pays both agents, and this is part of the closing settlement. When listing a property, the seller contracts to pay the seller's agent a commission, usually a percentage of the sales price, when the transaction closes. These commissions are typically in the range of 5 to 7 percent of the value of the property. (note 5) In all states of the United States, agents are affiliated with a real estate firm that employs, or is headed by, a broker. Real estate firms range in size from a single agent-broker to dozens of agents along with clerical and managerial staff. Some agencies are franchises of national chains (e.g., Better Homes and Gardens or RE/Max); others are local. Agents enter into listing contracts on behalf of the broker, get a variety of services from the firm and, in return, give the firm a share of their commissions. These relationships are contractual, as agents are independent contractors rather than employees of the agency. A highly productive agent has the bargaining power to negotiate for additional services or a more favorable division of the commission. In other words, the organizational structure of the real estate industry is primarily contractual, agents essentially act as "companies of one." Independent agent-brokers provide their own resources.

Findings, Discussion, and Implications

The focus in this section is on the commonalities regarding the ways in which context, uses of Information and Communication Technologies (IC), and the effects of these uses can be seen across levels of analysis. In doing this, we acknowledge that these findings are not orthogonal, rather, they can be interdependent, leading to possibly reinforcing or contradictory observations in specific settings.

From our work we observe that:

1. *A functional view of computerization provides insight into how changes to work might be better understood*. The values of, and responses to, computerization of work are similar if compared by function.
2. *Articulation is an omnipresent part of the computerization of work*. Articulation appears to be a constant, and perhaps growing, component of computerized work. This contradicts the simple view that articulation is a transient effect of learning to use and make use of a new computer-based system.
3. We note that computerization, and particularly the increased emphasis on identifying and semiautomating work processes, leads to extended conflicts regarding *power shifts among different occupations that must work together*.

Functional Insights on Computerization

A functional explanation of work's computerization provides additional insight into the effects of using computer-based systems. In Table 3 we summarize these insights. In all three forms of work reported on here, the functional uses of the control elements of the various types of computer-based systems are limited. Moreover, control elements of computer-based systems are typically underappreciated and often actively resisted. Packaged software developers did not like the constraints of version control, the organizational technologists did not like project-control software, and real estate agents valued software that allowed them to monitor people visiting their properties or interacting with their Web sites. Agents did not like franchise-level monitoring of their sales and listings.

In all three work settings, production elements of the computer-based systems were often coopted in use. That is, their uses in practice were different from the intended (or designed-in) uses. Software developers made very selective uses of which production elements they used, though their work is enacted through programming environments and software-based development tools. Organizational technologists relied on a range of diagnostic, diagramming, and documentation tools. Simple digital forms were the primary production technologies used by real estate agents.

TABLE 3 Summary of the Functional Perspective on Computing

Function of Computing	*Findings*
Control	Limited use, often resisted. This contrasts with managerial perspective on the value of computing for control.
Production	Co-opted in use, not used as expected by designers or managers. Shaped by local use.
Coordination	Extensively used and valued. Often features of systems are co-opted for coordination functions.
Access	Extensively used, tied to both production and coordination.
Entertainment	Not explored in this study.

All three groups of workers used computer-based systems to access data. Reports, code libraries, and data (of all sorts) were often sought, used, and even stored. Software developers relied on the code repository of the CASE tool and created shared spaces for their work in the collaborative work space. The ERP is predicated on simplified data access and powerful query and reporting tools. The MLS and the search tools provided even greater access for both real estate agents and customers (albeit at different levels of access).

Coordination elements were used by all workers and were often seen as primary functional value of the system being used. All three sets of workers used e-mail often, leaving the e-mail application running continuously. Packaged software developers also coordinated via notes in code and on documents, using these as notes and as tracking documents. Organizational technologists made extensive use of Web pages (for meeting minutes and updates), listservs, and the telephone. Real estate agents were the most extensive coordinators; cell phones, faxes, and e-mail were considered indispensable. This is possibly because much of their work is about coordination and communication.

Omnipresent Articulation

The second common finding is the additional effort needed to use any computer-based system. Too often this extra work is conceived as merely a transient phenomena tied to implementation—a training and learning cost. Clearly implementation is a period of added articulation. However, our evidence is that any computer-based system adds work. That is, even if a computerization effort alters or removes some work, it adds other work. The added articulation work we observed includes:

- Effort needed to develop work-arounds and extra time needed for coordination (meetings, calls, and tracking of status) to oversee processes and data, work out problems, and plan (e.g., Suchman 1996, 2000).
- Increased cognitive loads placed on workers. This is often due to clumsy computerization. That is, as work pressures increased (perhaps due to temporal pacing), computerized systems often demanded more attention from their users or failed to work when needed (e.g., Woods and Patterson 2001).

Examples of the added efforts to develop work-arounds are evident in the organizational technologists' work. They struggled, on a daily basis, to adjust the functionality of the ERP to meet the needs of line workers, altering work practices, changing configurations, rewriting reports, and even developing PC-based databases and spreadsheets to supplement the missing features of the ERP. Software developers were also constantly working around the limitations of their programming environments. Given the need to work together, they even knocked down walls and reconfigured their computers so they could more easily work from a common screen (Sawyer, Farber, and Spillers 1997). A substantial portion of a real estate agent's job is coordination and articulation as they work to close a house. Their reliance on cell phones and mobile devices is reflected in their frustration when the phone does not work. As an aside, when computerization is conceived as a means to increase work productivity, articulation work is even more disappointing as it is often not expected or budgeted. Thus, the extra work is being done even as the expectations are that works should be easier.

Power Shifting

The third common finding is that computerization of work tends to lead to shifts of power. These power shifts often center on work structuring (or restructuring), changes to the locus of decision rights, rights of access, and/or the use of resources. These all play parts in the increased focus on governance of computer-system-dependent processes. In essence, these new semiautomated processes are a new form of organizing. For example, the bulk of computerization efforts in software development were to automate elements of the software development process. Organizational technologists participated in an increased automation of the processes of implementation even as that effort was designed to increase the level of automation in the organization's work processes. Real estate agent's were increasingly using computer-based systems to automate elements of their processes of finding clients (both buyers and sellers) and selling houses.

Examples of power shifts shaped the work changes from all three of our domains. Software developers strove to collaborate, even as they resisted managerial monitoring. Organizational technologists tried to retain oversight of the technical infrastructure and the project order, even as users and vendors gained more power. Real estate agents worked to differentiate their services and minimize the likelihood that they would be disintermediated (Sawyer, Crowston, Wigand, and Allbritton 2003).

From a computerization perspective, we further note that in these efforts, control and production functions were either underused or used differently than originally intended (or designed). This was especially the case if these functions were focused on controlling the worker. However, coordination and access functions were valued, used (!), and often appropriated for use by workers in ways not expected or intended (Eschenfelder and Sawyer 1998; Orlikowski 1993).

Another form of power shifting is the use of computer-based systems to do things unimagined at first (Sproull and Kiesler 1991). This is in contrast to first-order (simple automation) and second-order (new ways of working) effects. For example, the development of team rooms by software developers and the shifting of house searches to buyers (via searching the online MLS) suggest that computerization of work efforts can have unintended and unforeseen positive effects. This is likely due to the pressures of articulation forcing workers into having to confront, domesticate, and resolve the computerization efforts effects on their work. That is, long-term computerization efforts are socially shaped, and the systems are configurable (Quintas 1994; Fleck 1994).

Conclusion

In this chapter we have focused on the computerization of work. In doing this, we have shown that the computerization of work is intimately linked to the larger social context in which these efforts take place. We have also shown that a social informatics perspective provides a useful lens to help explore this cross-level relationship. Further, we developed a functional characterization of computerization and drew from our own empirical work to show how this characterization provides increased intellectual precision about computerization of work efforts. Finally, we have identified three common findings about the computerization of work. As we summarize in the last few paragraphs, these findings can serve as tentative propositions for researchers in this area, as a set of design parameters for computing systems developers, and as a set of guidelines for those involved in leading, managing, and supporting work.

For researchers in this area, the findings developed from our overview of computerization of work studies lead to three suggestions for future research. First, that the contextualist and sociotechnical orientation provided by social informatics is an important conceptual lens to guide future research efforts. Second, the functional characterizations of computing provides added insight into the possible roles of, and likely responses to, computer-based systems. Third, the three common findings are worthy propositions for future empirical testing.

For designers, there are at least two pieces of guidance that can be derived from the findings reported in this chapter. First, systems design must be rooted in a deep understanding of the work that the system is designed to enable or support. Second, characterizing computing as a set of functions suggests that designers work to relate how particular features of their system map to user functions, and, as a part of that, to amplify the systems coordination and access functions, while minimizing the control and production aspects. For systems designed to enable control and production, this further suggests that linking these functions with coordination and access functionality may lead to a higher level of acceptance and use. Although the findings from the work summarized in this chapter do not speak directly to entertainment functionality, we speculate that this is an increasingly important (or at least fertile) element to explore in future systems designs.

For those involved in leading, managing, and supporting work, the findings from this study provide two insights. First, and analogous to the advice we provide to designers, it is critical to understand the contextualized and often abstracted patterns of process that underlie knowledge-intensive work. Second, it is important to understand that the value propositions, acceptance, and uses of new computing systems can be better understood as differing by function. This understanding can guide implementation plans and future work design. For example, computerization of work efforts that allow for increased coordination, access (and possibly entertainment), functionality are likely to be more readily received than are those that focus on control and production. If control and production are the important functions being pursued in computerization of work efforts, they may be more acceptable to the workers if these goals are intimately tied to coordination and access (and possibly entertainment) functionality.

Returning to how we began this chapter, the attention and interest in computerization of work continues to be offset by the remarkably large number of these efforts that substantially underperform in practice. The way forward is not tied to developments of new and currently unknown new computing technologies as much as it is intimately tied to both a better understanding of the complex and contextual nature of work and to a better way to think of, describe, and design the computerized artifacts that might support work.

ENDNOTES

1. In reporting these numbers, we echo the concerns about estimating workforce numbers. See the NRC monograph and Kling (1990) for extended discussions on the problems with estimating workforce numbers.
2. This explicit relationship reflects the socio-technical nature of work. That is, the complex interdependencies among the technical elements of work (such as the uses of computers) and the roles, norms, actions, and values of the people doing the work are difficult

to treat independently. Socio-technical approaches to understanding work where first developed in the Tavistock tradition (Mumford 2000). Various forms of socio-technical theorizing such as social construction of technology (SCOT), social-shaping of technology (SST), and network models (such as Hughes' reverse salients and Latour's actor network theory) have been developed to guide the analysis of socio-technical relations (Mackenzie and Wacjman 1999).

3. Two pragmatic reasons further guided selecting these three forms of work and computerization. First, the contexts and their uses of computers were interesting to us. Given the extended field work that work studies entail and the multiyear nature of the work, our enthusiasm for doing this research hinged, in part, on our personal interests. Second, gaining access (both physical and legal) to sites and people in those sites led us away from some forms of work (such as biotechnology) simply because there were nonbiotechnology firms nearby. An overview of each of these three work milieus and the computerization efforts that we studied complete this section.
4. These are also known as integrated programming environments (IPE) and integrated development environments (IDE).
5. Although exact figures are not kept, using 6 percent as a base commission, in 1998 total commissions exceeded $38 billion. In 1999 this grew to be greater than $41 billion. Current exact sales price and sales volume data are available online from the National Association of Realtors at http://nar.realtor.com/research/home.htm.

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