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Learning About Information Technologies and Social Change: The Contribution of Social Informatics

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Social informatics is the body of research that examines the design, uses, and consequences of information and communication technologies in ways that take into account their interaction with institutional and cultural contexts. This article serves as a brief introduction to social informatics. Examples such as computer networks, scientific communication via electronic journals, and public access to the Internet are used to illustrate key ideas from social informatics research. Some of the key themes include the importance of social contexts and work processes, sociotechnical networks, public access to information, and social infrastructure for computing support. The article draws upon 25 years of systematic analytical and critical research about information technology and social change.

Keywords computerization, social change, organizational informatics, work, communication, knowledge management

We are in a new era of computerization in North America—one in which networked computer and communications systems are becoming part of the daily life of a significant percentage of the public. Allowing public access to the Internet was arguably the most pivotal public policy choice that stimulated this rise in networked computing. Other behaviors that helped to popularize interest in the these new technologies include high levels of symbolic support from the Clinton–Gore White House, and the enthusiasm of business, entertainment, and technology journalists about "information superhighways." The possibilities of widespread Internet use have also stimulated substantial developments in a variety of applications, such as electronic commerce, distance education, electronic publishing, digital libraries, and virtual communities.

The emergence of these new applications has excited considerable speculation about the social changes that could arise if these kinds of Internet uses were to become widespread. Would electronic commerce, as illustrated by Amazon.com and eBay, erode the markets of physical stores? Could distance education provide new opportunities for a sound, inexpensive, and convenient education at home? Would widespread distance education become commonplace and rapidly erode the demand for place-based colleges and universities (Noam, 1995)? Would electronic journals develop rapidly as low-cost alternatives to increasingly expensive print journals (Harnad, 1991; Fuller, 1995)? Would digital libraries erode the demand for "brick and mortar" libraries? In turn, if so much social activity shifted from face-to-face, place-based settings to these new online forums, would community life erode?

These are important kinds of questions to be asking now, especially while significant opportunities to shape these network-enabled activities still exist. Unfortunately, much of the writing about the social changes that these new information and communication technologies (ICTs) will or could catalyze has relied on oversimplified conceptions of the relationship between technologies and social change.

There has been a substantial body of analytical and empirically grounded research about ICTs and social change that could better inform these kinds of discussions. Unfortunately, the research articles are scattered in the journals of several different fields, including communications, computer science, information systems, information science, and some social sciences. Each of these fields uses

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somewhat different nomenclature. This diversity of communication outlets and specialized terminologies makes it difficult for many nonspecialists (and even specialists) to locate important studies. One impetus for coining a new term—*social informatics*—was to help make these ideas accessible to nonspecialists. The new appellation was also intended to strengthen communication between specialists, and to strengthen the dialogs between communities of designers and social analysts. *Social informatics* is the new working name for the interdisciplinary study of the design, uses, and consequences of information technologies that takes into account their interaction with institutional and cultural contexts.[1]

Social informatics is a field that is defined by its topic (and fundamental questions about it) rather than by a family of methods, much like the fields of urban studies or gerontology. Social informatics has been a subject of systematic analytical and critical research for the last 25 years. This body of research has developed theories and findings that are pertinent to understanding the design, development, and operation of usable information systems, including computer networks, electronic forums, digital libraries, and electronic journals. This article discusses some key ideas of social informatics and includes numerous references to help interested readers readily locate more comprehensive resources

EARLY RESEARCH IN SOCIAL INFORMATICS: ALTERNATIVES TO DETERMINISTIC IMPACT STUDIES

Throughout the 1970s and 1980s, much of the social informatics research focused on organizations because they were the major sites of computerization. It is only in the last few years that many people who are not technical specialists have gotten computer systems for home use. The era of the Internet, or, specifically, public access to the Internet, raises issues about changes in areas such as working at home, communication, entertainment, and other personal uses. These are significant phenomena but are not the topics I focus on in this article. They are part of the field of social informatics, but they open up different lines of analysis that warrant in-depth study and understanding (see, for example, Anderson et al., 1995; Kahin & Keller, 1995).

In the 1970s and 1980s, often the questions about computerization were phrased as deterministic impact questions, such as "What would be the impact of computers on organizational behavior if we did X?"; "What would be the changes in social life if we did X?"; "Will computer systems improve or degrade the quality of work?" There are a number of studies in which people attempted to answer this last question, that of whether work life would improve for clerks, for engineers, for managers, and so on. The questions were often phrased in very simple, direct terms, namely, "Which will happen, X or Y?" And the answer was, "Sometimes X, and sometimes Y." There was no simple, direct effect. Much of the character of change depended on the relative power of the workers. For example, clerks fared less well, on average, than professionals. But secretaries, who are the aristocrats of the clerical class, sometimes experienced greater improvements in their work lives than did the workers, primarily women, who were processing transactions in the back rooms of banks and insurance companies. Occupational power played an important role in mediating and shaping the way computerization restructured workplaces (see Kling, 1980; Attewell, 1987; Iacono & Kling, 1987).

Other sets of questions were also examined, such as To what extent did organizations become centralized after computerization? Strong arguments were made that computer systems would enable upper managers to have much more detailed information about the operations in workplaces (such as the shop floor, the editorial room, and the classroom) and that as a result, organizations would become more centralized. Others argued that they would become more decentralized. Many people wanted to know, "Well, which is it? Is it A or B?" Some studies found that information technology use led to some organizations' centralizing, while other studies found that information technology use led to decentralization. Many of the arguments that were framed in the form of "Is it A or B?" were based upon simple technological determinism, which has not been borne out in the reviews of the most methodologically sound studies (see King, 1983; George & King, 1991). The analytical failure of technological determinism is one of the interesting and durable findings of social informatics research.

Today some analysts (and many pundits) frame claims about information technology in social life in deterministic ways, with claims such as "The Web means that the public will get better information than ever before" or "University courses on the Internet will soon eliminate most 'place-based' colleges and universities." These are framings that people who study social informatics would be skeptical of. There is a large body of research about ICT impacts that reports that the consequences of computerization depend upon the context[2] in which systems are developed, implemented, and used (see Kling, 1980, for an early review of this literature).

As an alternative to the simple claim that the Internet provides better information, we ask contextual questions, such as "When will the Web enable the public to locate 'better information'? Under what conditions? For whom? For what?" For example, are people seeking information on the Internet to help them to better choose a doctor, and then placing more trust in that doctor? Or are people seeking alternatives to doctor-mediated medical

care, such as information about health, herbal medicine, or postoperative care?

As alternatives to the claim that Internet courses will replace traditional college education, we ask about the conditions under which people will prefer one type of educational experience over the other. For example, online courses may be desirable to adults who don't live near an appropriate university, while a place-based education may be sought by teenagers who are looking for a social experience as well as formal education, or by people pursuing education in fields that require expensive specialized laboratory equipment. We ask about the roles courses and degrees play in many people's lives. We would ask about the life circumstances that could lead millions of people of the kind who now seek courses and degrees in in-place colleges to abandon them for online courses and degree programs.

These contingency questions don't lend themselves to snappy sound bites. But they do yield a very nuanced conceptual understanding. This kind of contextual inquiry illustrates the ways in which social informatics researchers frame questions in order to develop an analytical understanding of information technologies in social life.

SOME KEY IDEAS OF SOCIAL INFORMATICS

Social informatics research has produced some useful ideas and findings that are applicable to many kinds of information technologies and shed interesting light on some facets of Internet use that I discuss. The concept of computerized information systems as "sociotechnical networks"[3] is one such idea that helps us understand the character of new electronic information spaces, such as discussion lists, groupware, electronic conferencing systems, and e-journals. The concept of sociotechnical networks helps analysts to overcome some key limitations of determinstic impact analyses. I introduce the concept and then develop it with several different examples.

Information Technologies as Sociotechnical Networks

To set the groundwork for sociotechnical networks, we start with a more general concept, that ICT, in practice, *is socially shaped*. In the standard (nonsocial informatics) accounts of ICT and social change, it is common to hear information technologies characterized as tools, and questions are asked about their social impacts (discussed earlier). For example, in the 1970s, several colleagues and I studied local governments to understand the impacts of computerized information systems on the nature of work, client relationships, and possible redistributions of power within organizations. However, we refined our views on the character of computerization and how to conceptualize ICTs during the course of conducting the research.

We found that local governments selectively adopted and developed different kinds of information systems, depending upon their form of internal organization. In some cities, a professional city manager's office or a central finance department exerted strong control over information systems developments. In these cities, the information systems development staff were often centralized and delegated projects to various departments. In contrast, other cities were much more decentralized and many departments, such as police or planning, controlled their own computer systems and their own information systems development staffs. In these cases, many more systems were tailored to help departmental managers better understand and control their functional areas. American local governments did not simply utilize computerized information systems. They organized their technical staffs in different arrangements and created different ICT pricing schemes for systems developments, reprogramming, and operations. They created different governance structures for regulating and directing their commitments to ICT. Professionals and managers who were seeking new information systems or changes in existing systems did not deal only with or even directly with computers; they had to mobilize an organizational system as well. We called this combination of equipment, people, governance structures, and ICT policies "the local computing package" (Kling & Dutton, 1982) (see Figure 1[4]).

The local computing package is also an example of a sociotechnical network. A sociotechnical network brings together equipment, equipment vendors, technical specialists, upper-level managers, ICT policies, internal funding, and external grant funding with the people who will use

- People in various roles and relationships with each other and with other system elements.
- Hardware (computer mainframes, workstations, peripherals, telecommunications equipment).
- Software (operating systems, utilities, and application programs).
- Techniques (management science models, voting schemes).
- Support resources (training/support/help).
- Information structures (content and content providers, rules/norms/regulations, such as those that authorize people to use systems and information in specific ways).

FIG. 1. Some elements of a local computing package.

TABLE 1
Conceptions of ICT in organizations/society

Standard (tool) models	Sociotechnical models
ICT is a tool.	ICT is a sociotechnical network.
A business model is sufficient.	An ecological view is also needed.
One-shot ICT implementations are made.	ICT implementations are an ongoing social process.
Technological effects are direct and immediate.	Technological effects are indirect and involve different time scales.
Politics are bad or irrelevant.	Politics are central and even enabling.
Incentives to change are unproblematic.	Incentives may require restructuring (and may be in conflict).
Relationships are easily reformed.	Relationships are complex, negotiated, multivalent (including trust).
Social effects of ICT are big but isolated and benign.	Potentially enormous social repercussions of ICT (not just quality of work life, but overall quality of life).
Contexts are simple (a few key terms or demographics).	Contexts are complex (matrixes of businesses, services, people, technology history, location, etc.).
Knowledge and expertise are easily made explicit.	Knowledge and expertise are inherently tacit/implicit.
ICT infrastructures are fully supportive.	Additional skill and work are needed to make ICT work.

Note: Adapted from Kling and Lamb (in press).

information systems in the course of other work (such as policing, accounting, taxing, or planning). These elements are not simply a static list but are interrelated within a matrix of social and technical dependencies.

Computing packages differed from one city to another. However, as the broad-brush sketch already drawn suggests, some were configured as rather centralized formations while others were more decentralized (and often more heterogeneous). The configurations of these local computing packages were influenced by the distribution of power within specific city governments—they were socially shaped. In turn, we found that the local computing configurations influenced both the mix of information systems in a city and the ways "similar information systems" were configured. We also found that the local mix of information systems and their uses in city decisions (such as annual budget hearings) tended to help reinforce the relative organizational power of the groups that exerted the most control over the local computing package (Danziger, et al., 1982). This pattern is an example of the concept of reinforcement politics.

During the course of conducting our research in the 1970s, we shifted from viewing ICT as having impacts to an appreciation that the impacts of ICT were socially shaped. We learned that complex equipment-in-use was necessarily embedded inextricably in a heterogeneous sociotechnical network. We also found that computerization was a complex and often lengthy sociotechnical process.

These sociotechnical concepts have been applied in subsequent research about the character of ICT in other kinds of organizations, including manufacturing; newer technologies, such as desktop computing in the 1980s and electronic journals in the 1990s; and larger-scale social settings, such as scientific communities and wired cities. Some of the ideas that developed from the sociotechnical networks approach are summarized in Table 1. These ideas derive from a much larger body of research (for recent reviews see Edwards, 1994; Kling & Jewett, 1994; Kling & Lamb, in press).

Before we discuss some applications of the sociotechnical networks approach, we want to explain one kind of highly intertwined sociotechnical interaction network model.[5] This model seems especially helpful in understanding electronic forums, including conferencing systems and electronic journals. In contrast, the characterization of the computing package separated equipment (or technology) from social relationships and resources. This analytical separation between artifacts and social worlds is very common, even in social shaping analyses. Some social informatics researchers have developed refined social shaping approaches (see, e.g., Barley, 1986; Poole & DeSanctis, 1989, 1990; Fulk, 1993; Fulk et al., 1995; Dutton, 1999). In these approaches, as in the concept of reinforcement politics, social relationships shape the kinds of artifacts selected, their configuration, and their typical modes of use. But artifacts are conceptualized as the products of engineering and as 100% separable from social relationships.

In the highly intertwined model, the technology in use and the social world are not seen as separate—they coconstitute each other. The model is highly (but not completely) intertwined because its adherents do not insist that this intertwining of technical and social elements is universal. Rather, it is commonplace, and a good heuristic for inquiry, especially with complex technologies. References to technologies and social entities and to the interactions

between them are made largely for analytical convenience. For example, one might say, "Indiana University is using Web boards to support class discussions when the participants are not in class together." Indiana University and its classes would be treated as social forms and Web boards would be viewed as material information technologies. In the highly intertwined model the Web boards could be examined to see how they are constituted as sociotechnical networks. For example, certain social relationships are inscribed into the Web boards when they are used (such as access controls that determine who can read and contribute to them). Other aspects of relationships are shaped by supporting social protocols about legitimate content (to what extent are jokes or advertisements allowed in a specific class's Web board?).

Similarly, Indiana University in Bloomington can be seen as being coconstituted with diverse technologies.[6] Its routine operations rest on a complex set of building technologies, heating/cooling technologies, food acquisition and preparation technologies, and information and communication technologies. Without these (and other technologies) we would have 35,000 students, 1500 faculty, and 2000 staff milling around in the forested hills of Bloomington, foraging for food and organizing themselves just by face-to-face conversation, word of mouth, and rumor! In contrast, the Indiana University of 1880, with about 300 students and a few dozen faculty, functioned with much simpler technologies than those that are required for the much vaster contemporary university. However, any means of recording information about enrollments, courses, requirements, and so on would require some kind of ICTs, however crude. In this sense, an organization such as Indiana University is composed not just of people in social relationships, but also of diverse technologies. In fact, one can interpret many of the discussions of Internet-supported distance education as efforts to constitute new kinds of universities by changing their ICT infrastructures and pedagogies.

The highly intertwined sociotechnical model seems especially useful for understanding the social shaping and "consequences" of ICTs that form the primary communication media for groups. But even a more relaxed social shaping model raises concerns about simple claims concerning ICT's impacts (such as "The Internet is democratizing politics").

Sociotechnical Interaction Networks: The Vitality of Electronic Journals

The use of the Internet to support scientific communication is one of the major shifts in the practice of science in this era, and it has generated much research and significant discussion. In the scientific communities, these communications include informal e-mail, the communication of conference programs as they gel, the sharing of preprints, access to electronic versions of journal articles, and the development of shared disciplinary corpuses. These communicative practices are becoming more important in many fields, although they are rarely the central communications media. However, only a few analyses take sufficient account of the ways in which the social dimensions of publications, such as the design of electronic journals, influence their use (see, e.g., Kling & Covi, 1995).

One common approach to conceptualizing new forms, such as electronic journals, online newspapers, electronic forums, Web sites, and digital libraries, emphasizes their technologically based information-processing features such as enabling authors and readers to communicate more directly, without the mediation of libraries or expensive publishers. The sociotechnical approach, explained next, views these new forms as mixing together technological elements and social relationships and creating an effectively inseparable ensemble.

From a technological information-processing perspective, new media such as electronic journals,[7] databases, and preprint servers are said to reduce the costs of communication, expand the range of people and locations from which materials are accessible, and generally speed communications. According to this view, as scholars in all scientific fields work with data and communicate both formally and informally with other scholars, all of these electronic media forums should be adopted and used fairly uniformly. Differences in value would rest upon the differences in technical architectures. For example, readers would be more likely to read electronic journal A rather than journal B if journal A added more informational value, such as having an elaborate set of cross-links between articles or including more extensive sets of data and graphics.

Even the strongest proponents of electronic journals agree that technological design alone is not sufficient to ensure the quality of a journal. There is a strong consensus that the quality of a journal's scholarly content is important in making it viable, but there is substantial disagreement about the means of attracting high-caliber materials. All the proposals and counterproposals for attracting high-quality authors rest on social analyses of a journal, rather than on purely technological analyses. For example, one aspect of electronic journals that is commonly discussed is the role of peer review.[8] There are many ways of organizing peer reviews, but all of the strategies for selecting reviewers and translating their assessments into feedback for authors and publication criteria for the journal are social processes. These social processes are supported by communication media, and the electronic media may

facilitate or inhibit specific ways of organizing reviewers, reviewing, and editing.

The value of a sociotechnical analysis can be illustrated by contrasting the design and functioning of two electronic journals: *Electronic Transactions of Artificial Intelligence* and *The Electronic Journal of Cognitive and Brain Sciences*. Superficially, these scientific electronic journals have much in common: Each is hosted on a Web site, relies upon peer review to select high-quality articles, and posts articles for public prereview before they are accepted or rejected for formal publication. Both journals were established in 1997 and have had about 3 years of activity to establish a publishing pattern. These two journals are especially interesting in terms of the ways in which their designers envision attracting authors to submit high-quality articles and ensuring that only high-quality articles are actually published.

However, one of these journals seems to be viable while the other seems moribund. The technological publication system for each journal functions effectively, and I indicate next how the differences rest on their design as sociotechnical interaction networks. Rather than analyze the journals as I describe them, I believe that it would be useful for readers to note the contrasts in the two journals' designs and to try to deduce which journal is the more viable and why.

Electronic Transactions on Artificial Intelligence (ETAI). The ECCAI (European Coordinating Committee for Artificial Intelligence) announced the *ETAI*[9] as a journal in May 1997, with Professor Erik Sandewall, a pioneer of artificial intelligence research in Scandinavia, as its editor in chief. The journal's editors and organizers sought to make the review process of articles more open for authors and readers by making some aspects of an article's review very public. *ETAI*'s editors claim:

> The ETAI represents a novel approach to electronic publishing. We do not simply inherit the patterns from the older technology, but instead we have rethought the structure of scientific communication in order to make the best possible use of international computer networks as well as electronic document and database technologies.

They describe their editorial process as follows:

> Articles submitted to the ETAI are reviewed in a two-phase process. After submission, an article is open to public online discussion in the area's News Journal [part of the journal's Web site]. After the discussion period of three months, and after the authors have had a chance to revise it, the article is reviewed for acceptance by the ETAI, using confidential peer review and journal-level quality criteria. This second phase is expected to be rather short because of the preceding discussion and possible revision. During the entire reviewing process, the article is already published in a "First Publication Archive," which compares to publication as a departmental tech report. (From ETAI, 1997; see Sandewall, 1998, for a more elaborate description of this editorial process.)

The *ETAI* is divided into several topical sections, each section with its own section editor. The *ETAI* Web site has a public discussion section linked to each submitted article. An annual paper edition of the articles, without the discussion, is published by the Royal Swedish Academy of Sciences (KVA).

The Electronic Journal of Cognitive and Brain Sciences (EJCBS). *EJCBS* (http://osiris.rutgers.edu/~zoli/ejcbs.html) was devised by Dr. Zoltan Nadasdy of Rutgers University as an e-journal "that works without editors" and that offers the following features (Nadasdy, 1998)[10]:

> Instead of a hidebound peer-review system, we use an interactive "vote," in which those with comments and suggestions post them along with the article.
>
> Instead of a lengthy discussion carried out over a period of months and years as letters are submitted to journals and await publication, we allow anyone to post letters, and allow authors to answer them immediately.
>
> Instead of layout designers, we make use of . . . automated-formatting software that converts simple ASCII documents into HTML. The system supports graphical illustrations and automatically inserts them into the text. Hypertext is also inserted into the articles.

Nadasdy sought to devise "an autonomous system" that could run on its own after it was programmed. It would rely upon readers to be referees and not rely upon an editorial board. He designed it so "that [it] would be able to control itself based on reasonable rules." He developed software to automatically create a Web page with graphics for each submitted article, so that no human editorial activity would be required to post articles.

> EJCBS uses a two-tier acceptance procedure that makes reviewing automatic and allows readers to control final acceptance: review status and archive status. Papers in review status are evaluated by the readers . . . a weight system controls the score given by different reader categories. The scores are transferred to a database that will be averaged at the end of a month, and the final status of the paper will be decided accordingly. Articles that receive a certain average score, or higher, are transferred to an archive of accepted papers. Those papers that do not receive the minimal average scores are rejected.

Nadasdy designed *EJCBS* to improve the speed of publication, have low cost, enhance interactivity, and enable broad distribution. He claimed that "those features are all integrated into the system I call 'interactive publishing.' The impact of interactive publishing could be enormous. It redefines concepts of traditional publishing, such as editing, acceptance, reviews and comments, and archives."

The reviewing practices of *EJCBS* and *ETAI* differ considerably. *EJCBS* relies on anonymous reviewing by

(self-selected) readers. They visit its Web site and rate an article on several seven-point scales to indicate their views of its quality and importance. Nadasdy hoped that *EJCBS* could run itself and has tried to automate key editorial processes. It is an extreme example of removing editorial attention and guidance from the publishing process and relying upon a readers' plebiscite.

In contrast, an article that is submitted to *ETAI* is a topic for public discussion by participants in the research community. During the 3-month open review period, questions and comments are signed. In an informal reading of the discussions of several articles, I found that typically only a few questions were posted. However, they reflected a deep understanding of the topics, and some were elaborate counterexamples or reformulations of the authors' positions. Authors' replies were also public and seemed to engage the technical issues raised in the queries.

Both *ETAI* and *EJCBS* were initiated in 1997 and have had about three years of activity to establish a publishing pattern. These two journals are especially interesting in the ways that their designers envision attracting authors to submit high quality articles, and to insure that only high quality articles are published. Between 1997 and 1999, the *ETAI* accepted 58 articles for publication, while the *EJCBS* has only 6 articles posted for review, and none accepted.[11] The technological publication system for each journal functions effectively. The differences in their success rest on their design as socio-technical interaction networks.

For our post hoc analytical purposes, we can focus on the structural features of the sociotechnical model that I expressed in Figure 1. We view the design of *ETAI* and *EJCBS* not simply as one of artifacts, such as the compilers that Nadasdy developed to automatically translate submitted article files into postable Web pages for *EJCBS*. Rather, the interplay of social assumptions and practices that are reflected in technological design features helps us to understand the relative successes of these two e-journals.

In the case of *ETAI*, authors link up with potential readers through the journal's published articles. However, in order to have an article published, an author must be willing to discuss it in a public forum with other self-identified artificial intelligence (AI) researchers. This arrangement adds an important social and discursive element to publishing in the journal: Authors must be willing to participate in this part of the AI community by discussing their research. Publication in *ETAI* entails a set of relatively public social actions. Further, the editorial board of the *ETAI* was developed to include senior members of the European Coordinating Committee for Artificial Intelligence and paper publication through the Royal Swedish Academy of Sciences. Potential authors have good reason to believe that their articles will be known to participants in the European AI research community. According to Erik Sandewall, this visibility is a mixed blessing: It can enhance one's status for work that is well received, but it can also be embarrassing for authors whose work is ill-conceived, not well developed, or not well received.

EJCBS appears to be more problematic as a sociotechnical system. An author who submits an article will receive votes and possible comments from anonymous readers but does not have a forum in which to respond or develop a discussion with the readers. While *ETAI* has an editorial board whose members participate in a variety of high-status scientific social networks and promote the journal, *EJCBS* was designed by one relatively low-status and not well-connected bioscientist who would like to have it succeed autonomously, without any promotional or editorial attention. Authors who publish in *EJCBS* are not guaranteed any attention among highly active scientists in their field.

Nadasdy (personal communication, October 1998) believes that he has "shown that the (journal) concept works, and that people just have to come around to use it." His comment reflects a technologically focused view of e-publishing, one that pays much more attention to automating scripts and voting procedures than to seeking ways to effectively attract a lively group of authors and readers to the journal.

I have developed these two examples at some length because they demonstrate how a sociotechnical perspective on e-journals increases our understanding of how they may or may not serve as vibrant media for community communication. Nadasdy did "market the journal" by encouraging about 100 senior scientists to publish their articles in it. A few of them sent encouraging comments, but none submitted their research articles for review and possible publication. Nadasdy's software works; if an e-journal is viewed only as a technological artifact, then he has a working journal. However, as a genuine working journal requires a continuing stream of authors and readers, the design requires a more sophisticated social-technical approach than Nadasdy's.

The concepts just developed extend beyond e-journals to digital libraries, electronic forums, and so on. Further, the concept of sociotechnical interaction networks can help us understand some of the differences between World Wide Web sites and digital libraries that are highly used or little used. As technological systems, they are viewed only as collections of software, data (text, picture files, etc.), metadata (indexes, etc.), and links that run on networked computers. When they are conceptualized as sociotechnical interaction networks, the following elements are given special attention:

- People in various roles and relationships with each other and with other system elements.

- Support resources (training/support/help).
- Information structures (content and content providers, and rules/norms/regulations, including those that authorize people to use systems and information in specific ways and those involving access controls).
- The networks' content for various constituencies, who is authorized to change the content, and how that matters.

There are many such elements that connect technological artifacts to their social world. As a design practice, a sociotechnical approach also requires a discovery process that helps designers to effectively understand the relevant aspects of the lives and work of the people who will use their systems.[12]

How Social Context Matters: Intranets in Action

One way to illustrate a contextual inquiry of information technology and social behavior is to examine case studies of organizations. A particular example comes from the studies of how some consulting firms have adopted and used computerized documentary systems. One major consulting firm, identified by the alias Alpha Consulting, bought specialized equipment and 10,000 copies of Lotus Notes for their staff in 1989 (Orlikowski, 1993). Lotus Notes, a documentary support system, is superficially similar to an Internet-like system, with bulletin boards, posting mechanisms, discussion groups, and electronic mail for organizations. Depending upon how Notes is used, it can act as an e-mail system, a discussion system, an electronic publishing system, and/or a set of digital libraries.

Alpha Consulting is an international consulting firm with tens of thousands of employees worldwide, about 10,000 of those employees located in the United States. Their director of information and technology believed that Lotus Notes was such a powerful technology that its usefulness would be patently evident, and that the main thing to do was to rapidly roll it out to the consulting staff and let them use it to find creative ways to share information. The director of information and technology felt that Lotus Notes was so revolutionarily valuable that people didn't even have to be shown illustrative business examples its use, and that providing examples would be counterproductive as it might stunt employees' imaginations. The consultants should simply be given an opportunity to use it, and they would learn how to use it in creative ways.

The director of information and technology was concerned that his firm was employing thousands of "line consultants" in different offices all over North America who were working on similar problems but rarely sharing their expertise. Sometimes a consulting team in Boston would be dealing with an issue very similar to one being handled by a consulting team in Toronto or San Francisco. The consultants had no easy way of sharing with consultants in other offices their solutions to the problems they were facing. Could the firm's line consultants use some kind of communication and computerized information system to store what they knew and then share it?

The first test of Lotus Notes involved the information technology staff. They tended to use Lotus Notes; they found it interesting and used it fairly aggressively for sharing information about their own projects. Alpha Consulting's tax consultants in Washington, DC, were another group that used Lotus Notes. These tax consultants studied the behavior of the Internal Revenue Service and the U.S. Congress and disseminated tax advisories to Alpha Consulting offices around the country about changes in tax legislation that might affect their clients. These tax consultants made substantial use of Lotus Notes to broadcast their tax advisories.

The line consultants were intended to be Lotus Notes' primary users. However, organizational informatics researchers found that the senior line consultants, who were partners in the firm, tended to be modest users, while the more numerous junior line consultants, called associates, were actually low users. They often seemed uninterested in learning how to use Lotus Notes, readily gave up if they faced early frustrations with Notes, and as a group did not spend much time with it. Here we have a pattern of different groups within an organization having different practices in working with Lotus Notes. How can we explain such differences?

One explanation focuses upon the incentive systems in the firm. A good place to start our analysis is with the associate consultants and the partners. Alpha Consulting—like many other large consulting firms in North America—reviews its consultants through a demanding promotion system. The associates receive an "up or out" performance review every 2 years. In the first few career reviews at major consulting firms, about half of the associates are fired. However, many of the associate consultants would prefer to be promoted to the status of partner. Consultants who are promoted to the status of partners can expect annual incomes of over $300,000 at these major firms. Partnerships are the golden ring that these firms use to motivate their associate consultants.

The associates are valued for their billable hours and are effectively required to bill almost all of their time. As they become more senior, their ability to attract new business becomes more critical. "Billable hours" means that they have an account that they can charge their time to. Lotus Notes, the revolutionary technology, was not provided to them with a training account to bill their time to. Consultants who wanted to use Lotus Notes had to have an account to charge their time against, and the initial learning time was on the order of 20 to 30 hours. In 1991, the consultants were billed at about $150 an hour, so they

had to find a client who would be willing to pay $3000 to $4500 for them to learn a system whose value wasn't yet clear to them. Many had trouble justifying that amount of expenditure to any of their clients at the time when they were participating in the Lotus Notes rollout. There was also an important question as to what the consultants would actually do with Lotus Notes after they learned how to use it. Consequently, relatively few associates saw much value in Lotus Notes, and there were no exemplary demonstrations showing them how other successful line consultants used Lotus Notes.

On the other hand, the partners had substantial job security (which was similar to university tenure). They could afford to experiment with Lotus Notes. They were more willing to invest some time to explore, often using e-mail, occasionally developing and sending memos, and so on. Overall, this case study contradicts the popular "Nintendo generation" explanation: "In the future, we don't have to train people about computing, because the Nintendo kids (or the Net kids) will learn quickly." In this case, the younger consultants generally had less incentive to learn Lotus Notes than did the middle-aged and elderly partners.

But what about the information technology staff and the tax consultants? These groups also had an advantage in their forms of job security. Many of the information technology staff were technophiles who were willing to work with an interesting new application. Lotus Notes has been helpful for people who can invest time in learning how to use it, especially when they have joint projects and substantial motivations for communicating, for documenting work, for sharing memos, and so on.

The tax consultants, who were located in Washington, DC, had a significant incentive to show that they were visible and valuable in the firm. In their case, fixed salaries not based on billable hours allowed them more freedom to explore Lotus Notes' uses. Lotus Notes allowed them to broadcast for visibility: It gave them the ability, in effect, to electronically publish their advice and make it quickly available to many of the consultants around the firm who wanted to read the Lotus Notes database. They hoped it would enhance their visibility and thus show that the Washington, DC, office was not just overhead but an important contributing part of the firm.

In short, although they proved to be of considerable importance, organizational incentive systems were not part of the original marketing story of Lotus Notes. It was the interesting information-processing features enabled by Lotus Notes that were emphasized in numerous stories in the technical press (see, e.g., Kirkpatrick, 1993.)

Different organizations, or different organizational subunits with different incentive systems, might use Lotus Notes very differently. The way some consultants in Ernst and Young (E&Y), another major consulting firm, use Lotus Notes is instructive (Davenport, 1997; Gierkink & Ruggles, n.d.). In brief, E&Y created an organization (Center for Business Knowledge) whose charter was to organize E&Y's consultants' know-how in specific high-profile areas. The new organization was staffed with consultants from other E&Y offices who were given 6-month assignments to play a special role as "knowledge networkers." By 1997, E&Y had developed 22 distinct cross-office networks of consultants with expertise in certain industries, organizational reforms, or technologies that were a focus of E&Y's business. Each consultant network was assigned a half-time person (the knowledge networker) to codify in Lotus Notes databases the insights from specific consulting projects, to prompt line consultants to add their own insights, and to edit and prune a project's discussion and document databases. In some cases, they developed topical "Power Packs" in Notes—a structured and filtered set of online materials, including sales presentations and proposal templates. Davenport observed that these knowledge networkers well understood their consultant network's topics, and that since these were short-term assignments for the consultants, they expected to utilize any newly gained expertise to advance their own careers when they returned to their consulting positions.

In this case, E&Y designed a human organizational "intelligence system" for sharing insights, ideas, and materials in specific topical areas. Lotus Notes served as an information support system—a medium for storing, organizing, and communicating these materials.

Taken together, these cases illustrate varied consequences of Lotus Notes' use in large consulting firms, as opposed to one fixed effect. Finding such varied, conflicting consequences in different settings is common in this body of research. Our job as researchers is not simply to document the various consequences of computerization, but also to theorize about them (see Lamb, 1996; Robey, 1997). For example, analysis of the different organizational incentive systems for different professionals increases our understanding of these disparate cases (also see Markus & Keil, 1994, for a case study of a little-used, large-scale expert system whose use was not supported by organizational incentive systems). It is possible that the way that Lotus Notes is used at both Alpha Consulting and E&Y has changed since the studies that inform this article were conducted. Our point here is not to praise E&Y and to criticize Alpha Consulting. Rather, it is to demonstrate how examination of their behavior allows us to develop empirically grounded concepts that help us to predict (or at least understand) variations in the ways people and groups use information technologies.

One key idea of social informatics research is that the social context of information technology development and use plays a significant role in influencing the ways in which people use information and technologies, and thus affects the consequences of the technology for work, organizations, and other social relationships. *Social context* does not refer to some abstract cloud that hovers above people

and information technology; it refers to a specific matrix of social relationships. In the cases just described, social context is characterized by particular incentive systems for using, organizing, and sharing information in different work groups and work roles. The different groups within Alpha Consulting and E&Y have different incentives to share information about the project know-how and thus the amount of use they make of Lotus Notes varies.

The cases of Alpha Consulting and E&Y also illustrate another important idea—that of conceptualizing the design of computer and networked systems as a set of interrelated decisions about technology and the organization of work. Unfortunately, thinking and talking about computerization as a development of sociotechnical configurations rather than as simply installing and using a new technology is not commonplace. It is common for managers and technologists to discuss some social repercussions of new technologies, such as the sponsorship of projects, training people to use new systems, and controls over access to information. However, these discussions usually treat all or most social behavior as separable from the technologies, whereas these two cases demonstrate that it is critical to take a more integrated sociotechnical view.

A Sociotechnical Approach to ICT Infrastructures: Public Access to Information via the Internet

There are innumerable examples of the use and value of the Internet in providing new kinds of communications to support a cornucopia of human activities in virtually every profession and kind of institution. In the United States, the professional and middle classes have found the Internet to be useful for communication with some government agencies, some forms of shopping, tracking investments, maintaining ties with friends and family via e-mail, and as a source of entertainment.

There are also many examples of ways in which the Internet enables the middle-class public to have better access to important information (see Kahin & Keller, 1995). In the United States, the public is beginning to turn to medical sources on the Web, finding answers and information on Web sites, in discussion groups, and so on. People may be seeking either alternative medical advice or information about issues that their doctors don't address well. Surgeons, for example, may be very skilled in surgery, but they may not be very good at giving people an understanding of what it takes to go through the recovery process. People sometimes find that certain Internet sources can be extremely helpful as alternative sources of information or as supplements to the information provided by their physicians. Anecdotal evidence suggests that the Internet may provide the means for many middle-class people to bypass the medical establishment. Anecdotal evidence also suggests that doctors' responses to their patients' feeling better informed and thus sometimes questioning or challenging their advice ranges from encouragement to annoyance. The changes in the patient–doctor relationship that may eventually result are as yet unclear.

In the United States, Vice-President Al Gore promotes networking for libraries, clinics, and schools by arguing that if they are wired together, their use will improve public education and enable substantially improved public services. How to actually transform such networks into meaningful social support systems is a question that remains unanswered.

While affordable telephone service and Internet service providers (ISPs) are usually available in more urban areas (Kahin & Keller, 1995), access to ISPs, and even to basic telephone service, is more problematic in many rural areas. In 1995, about 28.8 million people in the United States 16 years of age and older had access to the Internet at work, school, or home, while 16.4 million people used the Internet, and 11.5 million used the Web. About 80% of these people used the Internet at least once a week. However, about 182 million people 16 years of age and older did not have access to the Internet (Hoffman et al., 1996). A 1997 nationwide household study found that computer ownership and e-mail access were rising rapidly: About 94% of households have telephones, 37% have personal computers, 26% have modems, and 19% have online access (McConnaughey & Lader, 1998). The number of people with Internet access continues to rise rapidly (NTIA, 1999).

It might appear that technological access is the primary roadblock to expanded Internet use. *Technological access* refers to the physical availability of suitable equipment, including computers that are of adequate speed and equipped with appropriate software for a given activity. Scenarios of "ordinary people" using the Internet often assume that computer support is easy to organize and that access to information and services is not problematic.

In contrast, *social access* refers to know-how—a mix of professional knowledge, economic resources, and technical skills—for using technologies in ways that enhance professional practices and social life. In practice, social access—the abilities of diverse organizations and people from many walks of life to actually use these services—will be critical if advanced technologies are to move from the laboratories and pilot projects into widespread use where they can vitalize the nation and the economy. Social access should not be viewed as an add-on to a technological structure. Many systems designers have learned, for example, that a well-designed system does not simply tack on a computer interface after its internal structure has been set in place. The design of human interfaces and internal structures is highly coupled for systems that effectively support people's work and communication (see National Research Council, 1997, for an integrated review). In a

similar way, social access is integral to the design and development of systems and services that are to be widely used.

Some analysts do not view the provision of social access to the Internet for ordinary people as problematic, since they believe that access costs will rapidly decline and the public's computing skills will continue to rise. In this view, time and market developments will resolve most access issues. In contrast, we believe that getting good social access to the Internet is likely to prove troublesome for many people, based on the findings of careful studies of computer and Internet use.

Although 50% of U.S. households may have computers now, organizations have been the major adopters of networked information systems, especially as implementers of advanced technologies. There are few studies of computer use in households. In one careful study of ordinary households (the HomeNet study), researchers found that using the Internet is too hard for many ordinary people (Kiesler et al., 1997):

> Over 70% of the households called the help desk. Calls to the help desk represented the behavior of some of the more sophisticated users. Less sophisticated users dropped out once they hit usability barriers. The kinds of problems logged by help-desk staff included problems in installing phone service, configuring the telecommunication software, busy signals (users often blamed themselves!), buggy software, inexperience with mice, keyboards, scroll bars, terminology, radio buttons, and menus. Yet, in our home interviews, we noted there were many more problems participants had not called about. . . .
>
> We thought that as everyone learned how to use the computer and what the Internet could do for them, the influence of their initial computer skill would decline with time. We were wrong. Even after a year of experience with the Internet, participants' initial computer skill still constrained their Internet usage. This result held across different gender and age groups.

These findings serve as a cautionary note about our expecting the North American public to rapidly form a network nation. One intriguing finding of the HomeNet project is that families with adolescents made much more use of the Internet than those without. We suspect that many of these teenagers became critical on-site technical consultants for their parents.

In fact, a recent large-scale study reports a widening gap in Internet use within the U.S. population (NTIA, 1999): The 1998 data reveal significant disparities, including the following:

- Households with incomes of $75,000 and higher are more than 20 times more likely to have access to the Internet than those at the lowest income levels, and more than 9 times as likely to have a computer at home.
- Whites are more likely to have access to the Internet from home than Blacks or Hispanics are to have access from any location.
- Black and Hispanic households are approximately one-third as likely to have home Internet access as households of Asian/Pacific Islander descent, and roughly two-fifths as likely as White households.
- Regardless of income level, Americans living in rural areas are lagging behind in Internet access. Indeed, at the lowest income levels, those in urban areas are more than twice as likely to have Internet access as those earning the same income in rural areas.

For many groups, the digital divide has widened as the information haves outpace the have-nots in gaining access to electronic resources. The following gaps with regard to home Internet access are representative:

- The gaps between White and Hispanic households, and between White and Black households, are now more than 6 percentage points larger than they were in 1994.
- The digital divides based on education and income level have also increased in the last year alone. Between 1997 and 1998, the divide between those at the highest and lowest education levels increased 25%, and the divide between those at the highest and lowest income levels grew 29%.

These are amazing findings, since the cost of purchasing an entry-level personal computer (PC) has declined considerably in the last few years. In addition, ISPs have become commonplace and connection costs have also declined. The costs of equipment alone cannot effectively explain these growing disparities (see Kling, 1999b).

Infrastructure for Computing Support Is Social As Well As Technological. PCs are much more complicated to install and use for a diverse array of tasks than are turnkey appliances such as televisions and videocassette recorders (VCRs). While it is a standing joke that most people don't know how to program their VCRs (and thus watch an LCD blinking 00:00), most people can reliably play a videotape and enjoy the resulting entertainment. In contrast, PCs that use networked services require much more complex configurations (including data rates and IP numbers) that can change with changes in network configurations and service providers.

Effective computer systems that use Internet services will require reliable complementary technological resources such as phone service and electricity, which, while generally available in urban settings, may be problematic after disasters or in remote regions. What is less well appreciated is how the infrastructure that makes computer

systems workable also includes a variety of resources that are social in character. Skilled technical installers, trainers, and consultants are the most obvious social resources. In addition, people who use advanced networking applications need to be able to learn from others how to effectively integrate the applications into their working practices.

There is some debate about how much computer use has simplified in the last decade. It has probably become easier to use a stand-alone PC right out of the box. However, the dominant operating systems, such as Windows 95/98/NT or Unix (and Linux), can still stump even experts when applications or components interact badly.

System infrastructure is a sociotechnical system since technical capabilities depend upon skilled people, administrative procedures, and so forth, and social capabilities are enabled by simpler supporting technologies (e.g., word processors for creating technical documents, cellular telephones and pagers for contacting rapid-response consultants) (Kling, 1992). Malfunctioning computer systems are not simply an opportunity loss such as a book that is bought but not read. When people organize their days around the expectations that key technologies will function correctly only to find that they don't, they then often spend considerable time attempting to get the systems to work, waiting for help to come, and so on.

Workable computer applications are usually supported by a strong sociotechnical infrastructure. The surface features of computer systems are the most visible and are the primary subject of debates and systems analyses. But they are only one part of computerization projects. Many key parts of information systems are neither immediately visible nor interesting in their novelty. They include technical infrastructure such as reliable electricity. They also involve a range of skilled support—from people to document system features and train people to use them, to rapid-response consultants who can diagnose and repair system failures.

Much of the research about appropriate infrastructure comes from studies of systems that underperformed or failed (Star & Ruhleder, 1996; Kling & Scacchi, 1982). The social infrastructure of a given computer system is not homogeneous across social sites. For example, the Worm Community System was a collaboratory for molecular biologists who worked in hundreds of university laboratories; key social infrastructure for network connectivity and (Unix) skills depended upon the laboratory's work organization (and local university resources) (see Star & Ruhleder, 1996). Researchers found that the Worm Community System was technically well designed, but it was rather weak as an effective collaboratory because of the uneven and often limited support for its technical requirements in various university labs. In short, a weak local sociotechnical infrastructure can undermine the effective workability of computer systems, including those in people's homes, as I have already discussed (also see Haddon & Silverstone, 1995). The policy implications of this analysis are that organizations that work to provide Internet access for disadvantaged groups, such as students in less well-funded schools or working-class adults in rural areas, should provide a social infrastructure as well as equipment.

HOW SOCIAL INFORMATICS MATTERS

Social informatics research pertains to information technology developments and uses in any social setting, not just organizations. Social informatics researchers are especially interested in developing reliable knowledge about information technology and social change based on systematic empirical research in order to inform both public policy issues and professional practice. Our concepts and analyses provide increased understanding of the design, use, configuration, and/or consequences of ICTs so that they are actually workable for people and can fulfill their intended functions.

This careful contextual and empirically grounded analysis contrasts with high-spirited but largely a priori promotions of technologies that may occasionally work well for some people and may occasionally be valuable but are sometimes abandoned or unusable and thus incur needless waste and inspire misplaced hopes. In this article I have discussed a variety of ICTs, including local government information systems, computer networks, electronic journals, and the Internet. I have described two cases in which ICT professionals and managers relying on the standard tool model (as outlined in Table 1) devised systems that were underused relative to their potential and the expectations held for them. These are not just isolated examples; they represent a widespread phenomenon. Various studies (e.g., Kling & Scacchi, 1982; Kling, 1992; Markus & Keil, 1994; Attewell, 1996; Suchman, 1996) have shown that utilization of the conventional tool model can result in considerable losses of various kinds (e.g., money, time, productivity, efficiency). However, because many of these losses occur behind closed doors, they may be unseen by the general public. Indeed, even those who observe them may not be fully appreciative of their scope and depth, being unaware of the extent to which other groups suffer similarly or the degree to which things could have been different.

The standard tool model tends to both underestimate the costs and complexities of computerization and overestimate the generalizability of applications from one setting or group of individuals to another. The problems resulting from the use of this model may be likened to an invisible health problem such as migraine headaches. Those who suffer from migraine headaches experience severe pain and the resultant missed opportunities, decreased productivity, and generally reduced efficiency.[13] Others who

live or work with them can also be distressed or discommoded by the increased emotional volatility or unreliability caused by their ailment. However, many of us are almost completely oblivious to the chronic, but publicly invisible, suffering and loss being experienced by millions of people because of migraines.

In similar fashion, we may be ignorant of the needless waste and human distress that improperly conceived ICTs may cause. However, even if we do not work in an organization that suffers from poorly realized ICTs, these wastes and stressors may affect us more directly and more frequently than we realize. Financial losses by private organizations will result in our paying more for their products and services (although we may be unaware of the reasons for the price increases). Similar losses in public organizations may raise our taxes or result in a diminution of services. New services that we might want to try may prove to be considerably more frustrating than we anticipate. For example, there is growing evidence (e.g., Hara & Kling, in press) that many students in Internet-based distance education courses have been extremely frustrated when key participants (instructors, administrators, students) approached this as simply a new way to present courses and thus overlooked important (mis)communication behaviors. To be most effective, computerized distance education requires the recognition that new conventions are needed, such as the development of new communication practices under conditions of asymmetrical power.

Social informatics researchers study specific ICTs in specific settings to develop concepts and theories that apply to many kinds of ICTs in many kinds of settings. In each of the cases discussed in this article, I have shown how a social informatics analysis would have helped the participants to design or configure the ICTs differently or to alter some social practices in order to increase their usage. This is one important way in which social informatics matters and I have emphasized it in this article. This view of social informatics has important repercussions for public policy, professional practice, and the education of ICT professionals (see Kling, 1993; Kling & Allen, 1996; Kling et al., 2000). It is all too common today for ICT professionals, managers, and policy analysts to ignore or be unaware of that which has already been learned. Thus, each ICT community, such as electronic publishing, digital libraries, distance education, and electronic commerce, has to learn expensive lessons anew. A major concern of social informatics researchers is to develop a cumulative body of research that will help many people effectively shape ICTs so that they can improve people's work and lives. Such research is trans-technologies and trans-institutional— that is, it develops concepts and theories that are applicable to understanding numerous kinds of ICTs and a wide variety of social settings.

Social informatics research also investigates intriguing new social phenomena that emerge when people use information technology, such as the ways in which people develop trust in virtual teams (Iacono & Weisband, 1997) and the ways in which disciplinary norms influence scholars' use of electronic communication media (Kling & McKim, in press). But these phenomena would be the focus of another article. In this article I have identified a few key ideas that come from 25 years of systematic analytical and critical research about information technology and social life. These ideas include the following central concepts about social informatics analyses[14]:

- These analyses differ considerably from the traditional deterministic impact analyses.
- Such analyses consider an array of relevant factors, including social, cultural, organizational, and other contextual components.
- Work processes and practices need to be studied *for how they are actually carried out*.
- ICTs are more usefully conceived of as sociotechnical networks than simply as tools.

As we develop more elaborate ICTs and try to use them in almost every sphere of social life, we face fresh theoretical challenges for social informatics. Its possibilities and value are illustrated by some of the key ideas developed in this article—the social shaping of ICTs, the conceptions of highly intertwined sociotechnical networks, the roles of social incentives in energizing new electronic media, and the conceptualization of ICT infrastructure as sociotechnical practices and resources. The significance of social informatics research is continually expanding in this age of ever-increasing development of, and reliance on, ICT applications. Although ICTs are becoming more and more enmeshed in the lives of rapidly growing numbers of people, much still remains unknown about the ultimate social consequences of the ensuing changes. At this time, when significant opportunities still exist to shape the forms and uses of these new ICT applications, social informatics offers an indispensable analytical foundation.

NOTES

1. This definition comes from a workshop on Advances in Organizational and Social Informatics in the fall of 1997 that was sponsored by the National Science Foundation (see http://memex.lib.indiana.edu/siwkshop/SocInfo1.html). In addition, the workshop participants characterized social informatics research as analytical, critical, or normative. The analytical orientation refers to studies that develop theories about information technologies in institutional and cultural contexts or to empirical studies that are organized to contribute to such theorizing. I have emphasized analytical research in this short article. The critical orientation refers to examining information technologies from the perspectives of the people who might be using the technologies rather than those of the groups that commission, design, or implement specific

information technologies. The normative orientation refers to studies that make recommendations for professional practice or policy. Some of the analytical and critical research may be conceptualized and reported so as to help inform a normative stance. Social informatics has a Web page at http://www.slis.indiana.edu/SI and a small collection of online discussion forums. The WWW page includes sections that list and link courses, research conferences, and degree programs.

2. It takes careful analysis to specify appropriately what "the context" means for a particular situation (see Kling, 1987).

3. We use the term *network* rather than *system* because these configurations are open-ended and not designed. "A network, by contrast, is loosely organized; often imperfectly integrated; has nodes that may be part of other networks as well; and can be reconfigured" (Edwards, 1998, 1999).

4. In subsequent research, we have referred to these relationships and dependencies as a "web of computing" (Kling & Scacchi, 1982; Kling, 1992). Here I'm using the earlier conceptualization of "computing packages" because that was what we used while conducting our research in the mid-1970s.

5. For other accounts that examine sociotechnical networks as complexes that intertwine social and technological elements as a complex admixture, see, Mansell and Silverstone (1995), Wellman et al. (1996), Bowker et al. (1997), and MacKenzie and Wajcman (1999, pp. 22–24).

6. This argument owes much to Strum and Latour (1987).

7. I focus on those electronic journals whose primary distribution medium is electronic, unless I note otherwise.

8. There are both substantial criticisms and defenses of peer reviewing (see, e.g., Hibbitts, 1996, 1997; Zariski, 1997a, 1997b).

9. See http://www.ida.liu.se/ext/etai/.

10. I have restructured Nadasdy's list to better fit this analysis.

11. It is worth noting that other refereed e-journals also publish only a few articles per year. While these rates are a small fraction of the number of articles published annually by quarterly paper journals, they seem to be typical of refereed e-journals in the mid-1990s. For example, *The Chicago Journal of Theoretical Computer Science* (*CJTCS*) published the following number of articles: 1995, 4 articles; 1996, 6 articles; 1997, 5 articles (see http://www.cs.uchicago.edu/publications/cjtcs/artides/contents.html). This journal has an editorial board of 41 members, but few of them publish in the journal. Even so, the MIT Press assumed publishing responsibility for *CJCTS* in 1998. The MIT Press has also changed the circulation policy from one that is "free" and publicly accessible to one that is restricted to subscribers. It lists over 60 institutional subscribers whose subscription price is $125/year.

12. These analytical ideas can also be applied to designing new ICT applications. Effectively designing sociotechnical networks also requires a set of discovery processes to help the designers understand which features and trade-offs will be most acceptable to the people who are most likely to use the system. There are a number of discovery processes for learning about the preferences of the men and women who are likely to use these systems. These discovery processes include workplace ethnography (Simonsen & Kensing, 1997), focus groups, user participation in design teams (Carmel et al., 1993), and participatory design strategies (Schuler & Namioka, 1993; Eckehard et al., 1997). These approaches differ in many significant ways, such as the contextual richness of the understandings that they reveal and the extent to which they give the people who will use the systems influence and power in their design. These issues are the subject of a lively body of research that overlaps social informatics. However, to discuss it in detail here would lead us away from our focus on the structural elements of a sociotechnical analysis.

13. For example, a recent study estimates that the effects of migraine headaches cost American employers approximately $13 billion each year, with another $1 billion per year being spent on direct medical costs (Hu et al., 1999).

14. For more expanded reviews of social informatics research, see Kling (1993), Kling and Allen (1996), Bishop and Star (1996), Kling and Star (1998), Sawyer and Rosenbaum (2000), and Kling et al. (2000). For research anthologies see Dutton (1997), Huff and Finholt (1994), Kling (1996), Kiesler (1997), Smith and Kollock (1998), DeSanctis and Fulk (1999), and Kling and Lamb (in press).

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