Patricia Sachs

A major challenge for most corporations is the process of restructuring the work environment to meet and beat the competition. One design approach incorporates an **activity-oriented view** *of the situation, and it all starts by taking a clear look at the big picture*

Transforming Work: Collaboration, Learning, and Design

In recent years dramatic changes in the world economy have led companies to restructure themselves in order to compete globally. Debates in the academic community about the changing demand for workplace skills with the globalization of the economy are paralleled in the business literature about what it takes to create a productive business (e.g., [8, 22, 24]). Business goals for such improvements as computer systems, work systems, or learning organizations are heavily influenced by underlying assumptions about how people work and how organizations function. In this article I examine these underlying assumptions and outline their implications for design.

I suggest that underlying assumptions rooted in different conceptions of work coexist within an organization and represent different lenses through which people in the organization peer. One such lens, or conception of work, I call an "organizational, explicit" view, the other an "activity-oriented, tacit" view (see Table 1). Each of these perspectives carries different implications for the design of work and technologies. [1]

An organizational perspective on work is an explicit view and is represented, for example, by sets of defined tasks and operations such as those described in methods and procedures, which fulfill a set of business functions (the work-flow approach reflects this; see [16].) This view of work differs from an activity-oriented approach, which suggests that the range of activities, communication practices, relationships, and coordination it takes to accomplish business functions is complex and continually mediated by

[1] I have argued this in a recent article, "Shadows in the Soup: Conceptions of Work and the Nature of Evidence" [17].

workers and managers alike. An activity-based view of work analyzes everyday work practices to demonstrate the ways employees actually make the business function effectively. Taking a look at whole activities as distinct from only particular tasks means taking a look at how working people communicate, think through problems, forge alliances, and learn as a way of getting work done. An activity orientation draws on insights about work practice from several disciplines, including anthropology, history, and psychology, and in so doing provides a holistic approach to the analysis of work.[2] All work is characterized by explicit and tacit elements. I argue that designs for workplaces are often influenced by only one view (generally the organizational).

The data I describe in this article was gathered during a work redesign project in a telephone company from 1991–1992. I was a member of a facilitating team and worked closely with a design team for a year. The facilitating team was composed of employees of NYNEX Science and Technology (an anthropologist, a knowledge engineer, a process modeler, a telephony veteran, and a member of the Quality Institute). The design team was composed of eight people from the operating company, four union workers and four first-line managers, all of whom were "hands-on" workers in the process being redesigned. Together, we analyzed a work process in the company using a variety of methods from ethnographic research to computer modeling and the design team developed and implemented a redesign of the work process in the company.[3] A number of other redesign projects were underway in the company at the time we conducted our project.

Table 1. Work is both explicit and tacit

Organizational View Explicit	Organizational View Tacit
Training	Learning
Tasks	Know-How
Position in hierarchy	Informal political systems, network of contacts
Procedures and techniques	Conceptual understanding
Work flow	Work practices
Methods and procedures	Rules of thumb, judgment
Teams	Communities

Our project differed from the others in its fundamental approach. All other projects utilized a task-analysis approach[4] and conducted the analysis with consultants and individuals who did not actually perform the work being redesigned. Our project specifically worked in a participatory, action-research mode: The facilitating team explicitly shared ongoing research findings with the design team, and together we reflected on the implications of the research for design. Ours was not a pure research effort but a project driven by business needs and goals that we designed as a research-in-practice effort. We chose to conduct the project as reflectively as possible, and intentionally counterposed different approaches (ethnography, task modeling, and quality exercises) in order to work as holistically as possible. It was this diversity of approaches we embraced that led us to think critically about the implicit theories we saw operating among workplace participants. These implicit theories, which I describe here as organizational and activity-oriented thinking, have a profound influence on shaping design ideas. In this article, I have situated our own experience in developing a participatory work system design in the research literatures of anthropology, cognitive science, developmental work research, and business process analysis.

Studies of actual work practices (e.g., [1, 4, 7, 9–15, 19, 20, 23, 25]) have yielded evidence that the efficiency of work is in fact determined not so much by the logic and sequencing of task flow as by the capabilities of people for troubleshooting vexing problems in complicated situations, which inevitably arise in all workplaces. The studies have produced evidence that reveals the intelligence employed in everyday work practices is crucial for actually getting work done. In contrast to the notion that workers may be seen as cogs in a wheel, these studies suggest workers perpetuate webs of relationships in communities and it is within these human systems that problems are discovered and resolved and work is effectively accomplished.

When companies seek to transform the workplace (typically talked about as "reinventing the company" or creating a "nimble corporation"), they do so by employing a perspective that represents the point of view of only one part of this social complex of work: the organizational view. Commonly known as business process reengineering [8], this approach toward transforming the workplace fails to acknowledge how

[2] The activity-oriented approach is based in activity theory. I implicitly follow the thinking of Sylvia Scribner and works of Vygotsky in thinking about knowledge, skill, and conceptual development in adults. Essentially, activity theory takes an approach toward reasoning that is best understood through the activities in which people engage, since it is in activity that both social and psychological processes are intertwined. For the purposes of this article, activity theory provides a framework for focusing on skills and distributed problem-solving, both of which demand that people share under-standing in order to perform expertly.

[3] The project, known as the "T.1 redesign project," won internal awards for its design, implementation, and business results. See [5] and [3] for further descriptions of the project.

[4] That approach was known as "Rummler-Brache." I compared it to our approach in [17].

work is carried out in practice and the part human ingenuity plays in it [19]. Business process reengineering views work as a *process flow,* or the sequence of tasks in operations. It does not view process as practice but as a sequence of business functions. I argue here that (1) if only the organizational (explicit structural) features of work are considered in designing work and (2) the importance of learning is left out, there will be negative consequences in the conception and implementation of design.

Table 1 represents the different elements that together comprise work. The organizational view features explicit ways of looking at work, that is, those things that are documented, visible, and articulable. The work practice view features tacit elements of work, or those aspects that are silent and understood by the group. When workplaces and technologies are designed from an organizational perspective, the explicit aspects of work become highlighted, while the tacit ones are at placed in the background and not included for discussion.

I address the implications of employing an organizational perspective and an activity-based work perspective for the design of work environments (by which I mean the design of jobs and technology), by examining the way a particular technology has been used in the telephone company.

A Real World Case: The Trouble Ticketing System

The Trouble Ticketing System (TTS) is a large database that also functions as a scheduling, work routing, and record-keeping system. It is an example of a technology that was conceived from an organizational perspective. TTS was developed in the early 1980s and has functioned for the past several years to dispatch work to telephone company workers in order to schedule them and keep an electronic record of their work activities. TTS is centrally located on a mainframe computer, so that when it dispatches a ticket to a worker, it sends the ticket to the central office where the worker is located. The TTS ticket is logged in the computer, where a worker picks it up and begins to do the job. When finished, she or he picks up another ticket for the next job. While job tickets themselves are not new (they were used long before computerization was introduced), their role in the TTS system is:

> *...Before TTS, if, say, a tester had a problem on a line, you got no dial tone, it was open, that tester would call in. You'd pick up the phone, and he'd say, "I got no dial tone." And you would write the ticket out and you got all the information you needed... It was personable. You would talk to the person and get exactly what the trouble you caught was, what they needed, what they wanted. You could work with them on the phone and say, "OK hold on" and then get on to your test and say "I'm seeing it open back towards the frame. Did you check the frame?" "No, I didn't, I called you first." "OK."*

The old system allowed workers to talk to one another. In these conversations, they compared notes about what was going on at each end of the circuit. If there was a problem, they figured out what it was and worked on it together. These trouble-shooting conversations provided the occasion for workers to understand what was actually going on in the job, diagnose the situation, and remedy it:

> *You [used to] have a list of phone numbers. And you would call directly into the CO and you would get the guy who was working on the DSX8, say, that day. Whoever was assigned to it. And you know, it usually worked pretty good. If I had a problem, I could call up and say, "Hey, Jack, listen I got this problem, can you help me out?" Jack and I would work on it together and get it done and [snaps fingers] it's done.*

In contrast to this mode of operation in which workers discuss the problems that come up in the course of doing the job, TTS was designed to eliminate conversations. The driving reason for this was the idea that workers were not working in a highly efficient way when engaged in conversation. Conversations, from the perspective of the organization, were seen as time spent "off-task."

TTS was set up with the assumption that any worker trained in a job can do the job. The great advantage of this system, from the business (organizational) perspective, was that orders could be handled as they came up and wouldn't get caught in a bottleneck. This seemed like a reasonable and efficient way to route work orders. In addition, TTS could free workers from getting tied up in time-consuming trouble-shooting and creating bottlenecks. It did this by having them send a trouble ticket back to the mainframe, which would then dispatch it to a worker at the other end of the circuit, leaving the first worker free to pick up the next job in the queue. In practice, this meant that a worker got a job and encountered a problem (like no dial tone). Instead of then calling a co-worker at the other end of the circuit, he would send a trouble ticket in to TTS and then pick up the next ticket it sent out. Rationally, a worker lost no time on the phone, and the problem would be efficiently sent back to the system, which would generate another ticket to send to another worker.

From the worker's perspective, one of the effects of electronic dispatching was that it got in the way of being able to work out the kinks in a job:

> *So now with TTS, they send you a ticket. And a lot of these guys don't verify the frame. They just say, "Oh, it's open, its gotta be carrier," and they ship it in to carrier (e.g., they send it to TTS, which dispatches it to the other department). So, now the carrier person pulls this ticket, starts testing it, and goes back and finds out that it's carrying cable that's open on the frame... You don't have all the information on it. Today, you send the ticket and anybody can get it. You can get somebody who's brand new and doesn't know what they're doing. You can spend hours and hours working, you may get*

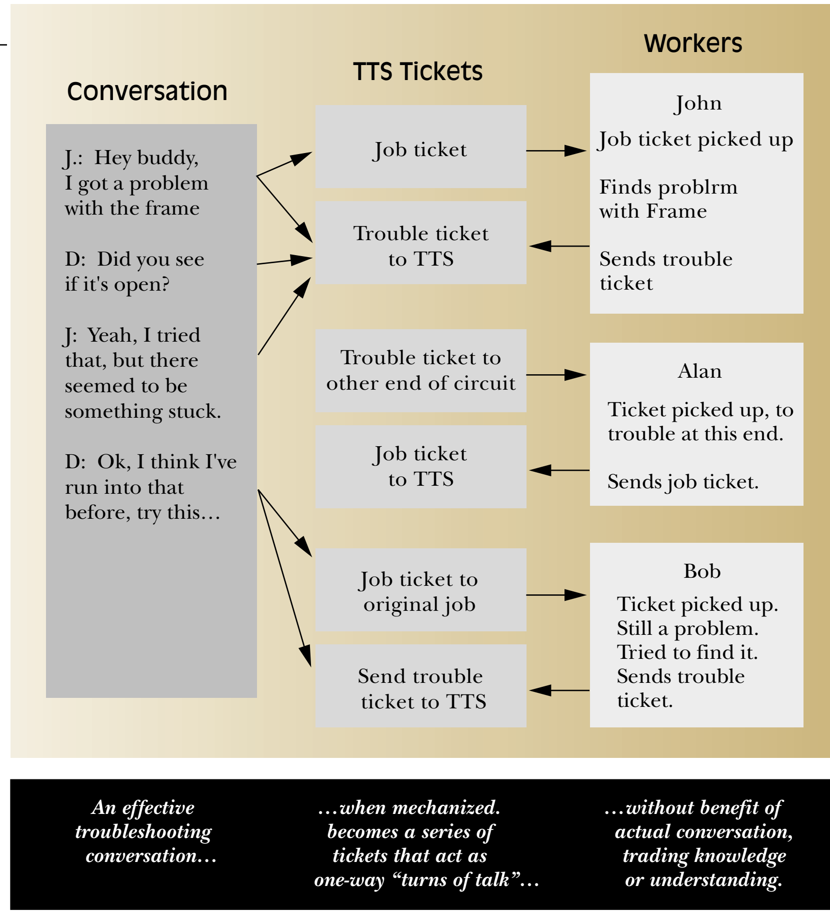

Figure 1. Effective conversations become a series of unrelated tickets

the ticket back (or someone else might pick it up). Let's say you ask for a remote loop, and they put up the remote loop and close out the ticket, send it back to you, and they'd say, "Send another ticket when you want the loop down." So, you lose that person. 'Cuz you can't talk to them...

Unlike a trouble-shooting conversation, in which two or more people can discuss a problem, explore the possible sources of the problem ("Did you check the frame?"), or decipher and interpret the information at hand ("I'd bet it's the wire since we saw..."), TTS translates conversations into a linear series of tickets unpredictably handled by an array of workers, none of whom speaks with another.

The translation of each turn of talk into a single ticket reduced an effective network of co-workers who could troubleshoot together into something like a relay race, handing off pieces of work to the next runner, creating an aggregate of dissociated workers. It changed a troubleshooting conversation into a series of solitary commands disembedded from context. Not only was the conversation—the story line of the problem, if you will—lost, so was the work community. (No one knew who else was working on the job.)

Figure 1 suggests conversations are a particularly effective form of communication, because in the course of a conversation elaborate and detailed information is exchanged, giving the speakers an opportunity to reflect on the problem, consider similar situations in which it has occurred, and figure out possible solutions. It is easier to solve a vexing problem when a worker can bounce ideas off someone else instead of relying only on his or her own experience to arrive at a solution. Orr [14] has demonstrated the power of exchanging war stories as vehicles for learning about ranges of problems and situations that serve as a fund of knowledge possessed by the working community. Workers draw on this fund of knowledge to help them troubleshoot. Conversations provide rich—if ambiguously structured—opportunities for tapping this fund of knowledge.

An activity-based perspective suggests that the whole activity of work in which a worker engages—in this case following a trouble from beginning to end, making sense of problems, conditions, kinds of orders, the routing of the circuit—reveals the importance of knowing in doing a job. By contrast, an organizational perspective honors the discrete and explicit tasks being performed rather than the thinking that produces performance of the task.

The underlying design assumption in organizational thinking is that technology design should eliminate human error. This differs sharply from the underlying assumption in activity-oriented thinking, which is that technology design should enhance the human capability of finding problems and solving them. Organizational thinking assumes that people create human error. Activity-oriented thinking assumes that people solve problems.

The work activity of constructing interpretations of work differs sharply from the task activity of moving stepwise through a straightforward procedure. An activity-based orientation reveals the sense-making and constructive interpretations in which workers engage; an organizational approach can never reveal these sorts of activities. To acknowledge them suggests that a core element of work involves learning by workers so that they can be effective troubleshooters.

In addition to distributing work, TTS was used to monitor the hours each worker spent doing jobs. This could actually interfere with doing a job well, since efficient work tends to be interpreted (and rewarded) as doing a job quickly, and doing several jobs a day. It frequently happens that doing a job well means taking longer to complete it since problems may arise that need to be dealt with. Taking the time to troubleshoot can mean doing work activities that cannot be accounted for by the system. TTS tickets are generated only for specific kinds of work (such as trouble tickets or job tickets) and not for other kinds of work:

> *See, I've got to account for my time with tickets. In other words, I can't be giving out freebies, I can't work and not get credit for it on my TTS. I wouldn't want to be starting carrier [today]. When I started I was trained by fellow guys at the CO, who were great. If I was starting … these poor guys I see, nobody helps them. They get tickets. Ticket comes in, foreman says "OK, you're doing specials today." "Specials, what's that?" So here, he gets a ticket, loads it to himself, now what's he do? Now he's walking around in a daze and nobody wants to help him . . . there's nothing I can say "I'm training him"; I can't put a "training ticket" in.*

While TTS was designed to make job performance more efficient, it has created the opposite effect: discouraging the training of new hands, breaking up the community of practice by eliminating troubleshooting conversations, and extending the time spent on a single job by segmenting coherent troubleshooting efforts into unconnected ticket-based tasks. These are dire consequences of a technology designed for efficiency. It is within work communities that new hands learn the ropes, peers consult on problems and extend their own understanding of an ever-changing technical profession, and workers share the tools and techniques they

Work and Infrastructure

Susan Leigh Star and Geoffrey C. Bowker

infrastructure [INFRA + STRUCTURE] A collective term for the subordinate parts of an undertaking; substructure, foundation. work What a person does or did; an act, deed, proceeding, business.
—***from Oxford English Dictionary*** *(Version 2.1 online)*

The 1971 Oxford English Dictionary contained no definition of infrastructure, but offered the Latin meaning of "infra"—"under the Forum, within the walls," often applied to new vernacular terms. "Computing infrastructure" or "national information infrastructure" are, of course, newcomers. But notions of "underneath" or "inside the walls" are still intuitively correct—infrastructure simultaneously represents work and effortlessly supports it, making possible collective accomplishment.

However, representing work is difficult, messy, complex, and often politically touchy. To capture (or classify) is to cut off, simplify, in some direction; work is notoriously slippery and situated. Whose voice, whose version will hold? Who benefits from which standards? One person's infrastructure may be another's barrier.

• The 100-year-old International Classification of Diseases (ICD) is an information infrastructure, established by the predecessors of the World Health Organization to collect morbidity and mortality data. Although it appears as a simple list, it reflects the national and professional judgments of doctors and public health officials. Thus, "to die in childbirth" has been negotiated between medicine and religion (Catholic and Protestant countries differ by as much as three years on what constitutes a stillbirth); "suicide" between civil and medical bodies (can children choose to kill themselves?). In some traditional Chinese and Indian medical systems, the very concept of disease is absent!
• Schlumberger's oil-prospecting infrastructure detects subterranean oil. Its first two patents worked because the methods both adapted to the oil company's work practices, and because Schlumberger engineers gained local field knowledge and contacts; as the technology became infrastructural, the company both conducted research and actively modified field practice to make essential their proprietary methods.
• The Worm Community System is a distributed virtual laboratory/community publishing information system for biologists. The range of skills and support at different locations is vast; adoption of the system relies simultaneously on its intellectual value and its organizational fit. If the local computing center cannot support Unix, the tool's sophistication will not matter; if the community routinely updates research quarterly, continual electronic publication may disrupt that rhythm.

Information infrastructures provide the tools—words, categories, information processing procedures—with which we can generate and manipulate knowledge. They also reify particular configurations of work practice by shaping the world within which tools can be used. Both the silences and the explicit categories are important for linking work and infrastructure— infrastructure development is both social and informatic.

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Tools for the Workplace

Brigitte Jordan, Ron Goldman, and Patricia Sachs

NYNEX Science and Technology and the Institute for Research on Learning (IRL) in Palo Alto, Calif., are working together to develop RepTools, an integrated package of tools for the collection, analysis, and representation of empirical data about the spatial, technological, physical and social realities of the workplace. These tools are intended to support the activities of individuals and teams that need to go beyond the official documentation of work processes to understand how work actually happens in real work situations. Embedded in the design of the tools are guidelines and suggestions, primarily stemming from ethnographic participant observation, for what sorts of things are important for representing the informal as well as the formal social, organizational and technological systems of work. The tools will allow designers and others to systematically collect data regarding the daily realities of worklife.

Though there will be many potential applications, we primarily conceive of RepTools as used by workers, managers and designers engaged in some form of workplace redesign. The tools will be of value when used by individual design team members. But we expect their greatest power to lie in supporting collaboration as team members use RepTool-generated representations to come to a shared, empirically grounded view of what is necessary to improve current work processes and practices.

A first prototype tool is now being field-tested. Called MapMaker, it is intended to help designers and researchers map out the spatial aspects of a particular work setting and to record the activities that take place in it. The information is collected in a database that is then used for individual and team analysis. Another tool being designed is RelationBuilder, a tool that design team members can use to represent the relationships between people, artifacts and systems as graphs or sets. For example, one might want to map relevant social relationships that exist in a workplace such as friendship networks, mentoring relationships, or current and previous work associations.

The same database will be used by both MapMaker and RelationBuilder, making it possible for information collected with one tool to be used when displaying information in the other. For example, it might be interesting to highlight the offices of all persons who belong to a particular work group, in order to study co-location. Future tools will focus on representing activities, tracking artifacts and documents, and providing time-based representations.

One of the central features of RepTools is they generate joint reflection on multiple levels, thus becoming "Tools for Learning" in organizational team settings. They support building an empirically grounded, shared view of the work practices that are to be redesigned, providing design team members with the ability to reflect on different data sets collected from similar environments, by multiple investigators, possibly at different times. By developing shared representations, they facilitate agreement on important patterns and relationships. RepTools can also stimulate and enable conversations between different levels of the organization, from front-line workers to senior management, thereby nurturing cross-organizational conversations that build a shared view of current realities and necessary changes.

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continually invent to handle situations that differ considerably from the plain vanilla version of work visible from the eye of the technology. It is within work communities that knowledge about how to get work done is stored and replenished. Work communities can provide "natural" arenas and systems for this collaborative learning to take place.

Implications for Design

The form of work organization supported by technologies such as TTS carries many assumptions about the nature and performance of work. TTS instantiates some of the key assumptions that are held in a rationalist and explicit view of work. In this view, work is seen as a discrete set of tasks that serve a highly focused purpose (creating the product through a specified set of business functions). The range of activities that workers must employ to actually get a job done, however, extends beyond the strict limits of a task into the less visible and more complex world of problem-finding, problem-solving, deciphering, decoding, understanding, and collaborating. These aspects of labor involve high-level thinking within particular work worlds. When technologies such as TTS, and jobs that support them, fail to take activities such as those involving skilled thinking into account, they ignore the flexibility of the practicing community in getting work accomplished, with the result of impairing the effectiveness of the system.

Although technologies such as TTS value efficiency and standardized worksteps over such activity as on-the-job problem-solving and peer-teaching are common, it is also true that most workers are dedicated to getting jobs done well and go the extra mile to do so. Overcoming constraints to get jobs done well frequently involves *workarounds*, or ways of circumventing the institutionalized practices that make it hard to get the work though the system. In the case of TTS workers soon got tired of being unable to track a job with a problem so they found ways to contact co-workers and used TTS to provide a formal record of the work, even though it might not have actually matched what they really did.

Workers easily recognize why workarounds are needed and are able to devise them whenever necessary. Workarounds are a form of on-the-job innovation that reveal the tension between the standards for a job and the realities of doing the work. While employees involved in doing jobs can easily converse about the details of why workarounds get jobs done, readily displaying their ability to think analytically about systemic problems and come up with solutions to them, this knowledge is generally not tapped for actual job design. In fact, workarounds are often talked about by workers as a sort of necessary evil, something that would not have to exist "if this place worked right." Because the people who design business processes are ordinarily not the individuals who do the hands-on work, and because business process designers tend to think organizationally rather than employing work thinking, the fund of knowledge about details of work process are generally not incorporated into work process designs.

While it may seem idealistic to suggest letting workers have a hand in the design of their own work environments, we in fact did succeed in doing so. The design team analyzed, among other things, the TTS system and its impact on the community of workers whose job it is to install circuits, several of whom were on the design team and were veteran telephone workers (see [3, 5]). We learned that teaching workers alternative models for analyzing work environments such as the contrast between organizational thinking and work thinking, gives them an opportunity to articulate and reflect upon their own observations about work practices that contrasts with the implicit models about "how to talk about and analyze work" that they all share.[5]

Specifically, the team of telephone workers noted how TTS effectively dismantled the system of direct communication between workers. By analyzing that process they conceived of a way to give direct and elaborated communication back to the workers by creating a new job ("turf coordinator") that created a worker role that coordinates and facilitates these communications. The turf coordinator is a experienced technician whose job it is to make sure the various field technicians responsible for installing a circuit get connected to each other by telephone. Since installing and testing a circuit can involve up to five people at different sites, the turf coordinator needs to know who these people are, and where they are located, and bridge them together in a conference call. Since the problems that can come up in installing a circuit are unpredictable and can concern a wide array of problems, the turf coordinator needs to know whom to tap from the people working during his or her shift and get them together.

This job was designed to circumvent the need for workarounds by paying attention to the work activities that actually get work done rather than focusing exclusively on the formal tasks of the job. Not only did this new job make use of workers' observations and analyses about the role of the work community in troubleshooting systemic problems, but when it was implemented it was (and continues to be) well-received by workers in the field. In fact, turf coordinators, field technicians, and their first-line managers meet regularly to identify problems and to solve them. These meetings might traditionally be viewed as time-consuming and off-task. However, several workers and managers in the telephone company have come to recognize the value of troubleshooting conversations that take place when a work community has the opportunity to flourish, providing the space for front-line workers and managers to develop their understanding of the overall work process. Occasions such as turf coordinator meetings function as learning environments for the people who attend them. Managers who support these sorts of activities have begun to see work in terms of activities, not just in terms of organizational tasks. Some of the distinctions between organizational and activity-oriented work thinking and their implications for design are summarized in Table 2. The TTS example suggests that an alternative perspective toward

Table 2. General design implications

Organizational View	Work/Activity View
Analytic Assumption:	**Analytic Assumption:**
People produce human error	*People discover problems and solve them*
Design Assumptions:	**Design Assumptions:**
Deskilling is desirable	Skill development is desirable
Routine work, rote thinking desirable	Development of knowledge, understanding, deciphering, is central to skill
Flexiblity = interchangeable jobs	Flexibility = skilled people
Standard Operating Environments are necessaryt to the business	Collaboration and collaborative learning take place in communities
Social interaction is nonproductive	Communities are funds of knowledge
Automation produces reliability	Skill through learning produces reliability
Consequence:	**Consequence:**
Learning is not encouraged	Learning is supported

[5] Initially, the employees discounted their own work practices, which included knowing how to negotiate the complex organization, in favor of more traditional views of their own work. It was only upon extensive discussion, data collection, and reflection that they began to integrate tacit elements of work into their analyses and design efforts.

work produces very different interpretations about what sorts of activities are defined as work and how jobs and technologies should be designed as a consequence. We are in an age in which fully-automated technology systems are highly regarded—robotized factories, fully automated flow-through provision of service, machines that "think"—all seem to be part of the plan. These designs of jobs and technologies follow logically from the premise that work can be viewed in terms of the business functions that need to be met rather than in terms of what it takes to actually get a job done.

Discussion

The transformation of workplaces is taking place in companies all over the country in many sorts of industries. It is affecting millions of workers, and is generally being conceived and implemented with the use of information technology. Ethnographic evidence suggests the very conception of work held in companies will affect the design of technologies and the design of jobs. What is not clear is whether new business designs will in fact support the tacit, informal social systems that exist in all workplaces, or whether those informal systems will devise ways to accomplish work despite the constraints of new designs.

It is clear that technologists and business design consultants alike recognize the need to take "the human system" into account in redesigning businesses. Their conception of the human system, however, appears to be in terms of individual psychologies rather than in terms of the ways in which the workplace environment is socially constituted. Such a view is aligned with a business function perspective in which individuals are viewed as the human parts, if you will, of the business system. This raises questions about the extent to which we acknowledge how the tacit aspects of work play a significant role in accomplishing work, which relies on the capacity of workers to identify problems, decipher them, interpret them within shifting situations, utilize formal and informal social networks in the organization, and draw on the fund of knowledge in the community. Designing environments and technologies to support these sorts of learning activities has the potential of influencing the transformation of work to support the development of expertise.

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