This paper lays the groundwork for new models of work and relations of production that reflect changes in the division of labor and occupational structure of a postindustrial economy. It demonstrates how new ideal-typical occupations can be constructed, drawing on a set of ethnographies to propose an empirically grounded model of technicians’ work. The paper focuses on two questions: What do technicians do and what do they know? The answers constitute a first cut at the ideal type, technician. The paper then turns to evidence of the difficulties that arise when organizations employ technicians but fail to appreciate the nature of their work. It closes by showing how a contextually derived model of technicians’ work enables us to evaluate why some recent trends in organizing are congruent with an increasingly technical workforce, why others may be misguided, and why organizations are likely to face challenges that organizational theorists have but vaguely anticipated. The paper shows that the emergence of technicians’ work may signify a shift to a more horizontal division of substantive expertise that undermines the logic of vertical organizing on which most organizational theory and practice still rests.

INTRODUCTION

History tells us that technology, organization, and work co-evolve. Although cause and effect are difficult to untangle, sweeping innovations in organizing seem to accompany fundamental changes in technology as well as broad shifts in what people do for a living. For this reason, one cannot explain the rise of corporations in the late-nineteenth and early-twentieth centuries without taking into account both the spread of such technologies as railroads, the telegraph, telephone, and electricity and such changes in the nature of work as the exodus from agriculture, the rise of management, and the rationalization of jobs (Nelson, 1975; Chandler, 1977; Hounshell, 1984; Beniger, 1986). Contingency theory and sociotechnical systems theory likewise attest to the inseparability of technology, work, and organizing. A central premise of both is that no organizational structure can be optimal unless it is tailored to the technology and the work it seeks to systematize.

Evidence that the nature of work in industrial societies is again in flux is indisputable. Blue-collar employment has fallen steadily since the mid 1950s, while white-collar jobs have expanded. Employment in service industries now outranks employment in manufacturing. Managerial work has become increasingly differentiated. Clerical employment has begun to wane. Together, professional and technical occupations, which exclude management and administration, now employ more Americans than any other occupational sector (Barley, 1996). Stable employment is declining, and contingent work is on the rise, even among professionals and managers. Computer technologies are eliminating some forms of work, creating others, and transforming a large proportion of what remains. It seems reasonable to expect...
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such changes should have significant implications for patterns of organizing.

Students of organizations do seem to sense that dramatic changes are afoot. Over the last decade many observers have spent much energy explaining why economic and technological developments demand extensive changes in strategy and structure (e.g., Womack, Jones, and Roos, 1990; Quinn, 1992; Hammer and Champy, 1993). Yet despite the field’s burgeoning interest in organizational transformation, researchers have paid almost no attention to how organizational developments might either reflect or affect the changing nature of work. When they mention it, researchers usually discuss work in terms of increasing complexity and interdependence, delayering, the permeability of tasks, and so on, concepts that essentially conflate work with forms of organizing. Discussions of what people do and how they do it are rare.

Organizational theory’s silence about work can be explained historically. One can argue that studies of work are simply not part of the field’s mandate. When organization theory broke from industrial sociology in the 1960s, its founders abandoned the study of work to solidify their jurisdictional claim. Work became the intellectual property of organization theory’s sister discipline, the sociology of work and occupations. Because early organizational theorists were committed to seeking general principles of organizing, when they found it necessary to talk about work, they turned to abstractions. With concepts like complexity and uncertainty, researchers hoped to level distinctions between work as dissimilar as management and medicine so as to discover relations that would hold across contexts. Moreover, the methods that organizational theorists preferred made it difficult to acquire first-hand knowledge of work practices. Cross-sectional surveys, lab experiments, secondary data, and interviews with top managers, in effect, distanced analysts from the details of work. Yet, as appealing as these explanations may be, if one could rewrite history to erase them, it is still not clear that organizational theorists could presently come to terms with changes in the nature of work. This is because the field’s inability to grapple with work also reflects a more subtle handicap that is not organizational theory’s alone: outdated images of work.

Antiquated Images of Work

Images of work have simply not changed as quickly as images of organizing. Over the last decade, new ideas for distinguishing organizational structures and strategies have proliferated. Adhocracies (Mintzberg, 1979), networked organizations (Powell, 1990), virtual organizations (Byrne, 1993), shamrock organizations (Handy, 1989), and lean structures (Womack, Jones, and Roos, 1990) are but a partial list. Many have come from studies of firms in high-technology and service industries, the vanguard of the post-industrial economy. In sharp contrast, we continue to think about work, even in high technology and service settings, with concepts and categories coined during the second industrial revolution or before. The possibility that our concepts for imagining work are more anachronistic than our
thinking about organizations is suggested by the formal systems we use to classify occupations, the cultural dichotomies we use to distinguish types of work, and the type of occupations that lurk in the background of our theories.

**Formal classifications.** Occupational sociologists generally agree that the detailed occupational categories by which the U.S. government classifies jobs are outdated (Spenner, 1979, 1983; Miller et al., 1980; Attewell, 1990; Steinberg, 1990). Since 1939 the Department of Labor has only incrementally revised the *Dictionary of Occupational Titles* (*DOT*), which represents the best source of data on the content of jobs in the U.S. economy. As a result, analysts can make much finer distinctions among blue-collar work than among managerial, clerical, service, sales, professional, or technical work. Cain and Treiman (1981) reported that 76 percent of the listings in the most recent edition of the DOT (U.S. Department of Labor, 1977) cover blue-collar jobs. Yet only 26 percent of all employed Americans are blue-collar workers, a decline of 14 percent since 1940. Seventy-two percent are employed in some form of white-collar or service work (an increase of 28 percent since 1940), and the remainder (2 percent) are farmers. Thus, researchers are forced to chart occupational trends with categories developed for an economy that existed somewhere between a quarter and a half a century ago.

**Cultural dichotomies.** Even more problematic is the fact that our everyday concepts for talking about work are relics of the industrial revolution. Dichotomies such as blue-collar and white-collar, mental and manual, worker and manager, and even the more juridical, exempt and nonexempt, are the legacy of a world in which one's standing rested largely on whether one's hands were clean or dirty at the end of the day. Although these distinctions are still important, their utility wanes with each passing year. For example, low-skilled service jobs may be just as unappealing as factory work, but they cannot be easily classified as blue-collar or even manual in the traditional sense of the term. The distinction between manager and worker also less adequately signals the nature of a person's work and status than it once did. Workers today are as likely to be engineers or programmers as they are machinists. Managers and administrators are as likely to have no employees as they are hundreds. Yet because these concepts have shaped formal as well as everyday theories of work, researchers who study the workforce and the workplace continue to spin out analyses predicated on their utility, often with less than satisfactory results. For example, attempts to extend deskilling theory to occupations like programming (Kraft, 1979) have proven questionable (Kuhn, 1989), largely because it is difficult to explain convincingly how execution could be separated from cognition in lines of work that had little manual content from the start.

**Ideal types.** Occupational images that structure our theoretical and intuitive grasp of the division of labor are also becoming anachronistic. Just as one can speak of ideal types that inform our thinking about organizations (Weber, 1968), so one can speak of ideal-typical occupations. An
ideal-typical occupation is an abstraction that captures key attributes of a cluster of occupations. As Weber noted, ideal types are useful not because they are descriptively accurate—actual instances rarely evince all of the attributes of an ideal type—but because they serve as models that assist in thinking about social phenomena. In much the same way that Weber used the ideal of a bureaucracy to develop his theory of industrial society, occupational sociologists have employed images of ideal-typical occupations as anchors for fashioning theories of work.

Ideal-typical occupations are also useful in everyday life, where they structure lay images of the division of labor. “The-worker-on-the-assembly-line” is one such ideal type. It invokes images of an individual, often in an automobile factory, standing beside a swiftly moving conveyor, repeatedly performing the same operation on each assembly that flows by. Boredom, fatigue, routine, lack of autonomy, and little need for thought or education are the hallmarks of such work. Although factory jobs have always been more varied than this, the ideal type nevertheless evokes a constellation of attributes that capture the family resemblance among many factory jobs. The clerk, the professional, the secretary, the farmer, and the manager are other prominent ideal-typical occupations.

Ideal-typical occupations are culturally and theoretically useful. By reducing the diversity of work to a few modal images, ideal types assist us both in comprehending how the division of labor is structured and in assigning status to individuals. They help parents shape their children’s aspirations. They provide designers of technologies with images of users. They assist sociologists in developing formal models of attainment. It is not clear how we could think in general terms about worlds of work without such anchors. The problem is that ideal-typical occupations are temporally bound.

Like occupational classifications and cultural dichotomies, ideal-typical occupations lose relevance as the division of labor and the nature of work change. For example, the ideal-typical farmer is an independent businessman laboring in the fields from sunrise to sunset with the assistance of a tractor, a few hired hands, family members, and little formal education, but extensive practical knowledge of crops, weather, animals, and soils. Modern farming bears little resemblance. Today, many farmers are subcontractors for agribusiness, have a college education, understand chemical properties of soils and fertilizers, and manage their farms with the help of computers. Nor is farming the only ideal-typical occupation whose utility can be questioned. Occupational sociologists have argued that our notion of the professional requires significant modification now that many professionals work as salaried employees (Derber and Schwartz, 1991; Wallace, 1995). Functional specialization even leads one to question whether ideal-typical images of a manager are still useful without extensive differentiation.

Why Organizational Theorists Need to Attend to Work

If organizational theorists wish to spin adequate theories, they may no longer be able to afford to separate the study
of organizations from the study of work and occupations. Without a substantive knowledge of work, organizational theorists risk building theories of change around terms with shallow content. Many students of organizations now acknowledge that service and knowledge work are becoming more common and that this will have far reaching implications for organizations (e.g., Blackler, Reed, and Whitaker, 1993; Winch and Schneider, 1993). Yet few scholars have explored in detail what these implications might be, in part because the data for doing so do not exist. There is almost no research on how service jobs differ from industrial jobs and even less information on how service jobs differ from each other. Much the same can be said for most forms of technical work. Furthermore, despite the general consensus that computer technologies are altering factories and offices, there have been relatively few studies of how factory work is actually changing and even fewer studies of changes in clerical work (for exceptions, see Majchrzak, 1988; Zuboff, 1989; Barley, 1990; Adler, 1992).

Organizational theorists even continue to speak of managers as a homogenous group, because the extensive occupational differentiation that has occurred in management has yet to attract attention. In the long run, an organizational theory that lacks detailed knowledge of work can conceptualize task systems only by resorting to either shallow generalities (e.g., we are becoming a nation of knowledge workers) or images of a division of labor from an earlier era. Neither approach is likely to satisfy tests of verisimilitude.

More fundamentally, in an era of widespread economic and technological change, understanding the changing nature of work is important to understanding organizing and reorganizing. As Scott (1981) noted, most contemporary organizational theory focuses on an organization’s relation with its environment. Although economic pressures, institutional changes, and population dynamics certainly shape organizational strategies and structures, organizations must still make choices about how to organize systems of work effectively to remain viable. Simply acknowledging that work is becoming more complex or interdependent does not describe a changing mode of production. Without answers to questions about what is done, how knowledge is distributed, and how exigencies of work and relations of production are structured, organizational theorists risk telling incomplete and even inaccurate stories about these choices and how and why organizations should change. For example, most commentators portray teams, flatter hierarchies, and network structures as ways to respond to environmental turbulence, lower labor or transaction costs, enhance commitment, reduce cycle time, increase flexibility, and so on. Such accounts are certainly reasonable, not only because they are consistent with previous organizational theory but also because they reflect the rhetoric that surrounds experimentation with such structures in industry. Yet because these accounts gloss over the issue of how work might be changing, they overlook the possibility of a deeper cause of change that may partially explain why such structures enable the aforementioned benefits. Suppose that work was changing such that expertise was becoming more technical, more unevenly distributed, and less readily
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formalized or rationalized. Under such conditions, society might witness the resurgence of lines of work organized along occupational rather than administrative lines (Freidson, 1973). Hierarchy and bureaucracy might then become less effective modes of organizing, not simply because the environment had become more turbulent but because authority of expertise and authority of position would less seamlessly coincide. In the remainder of this paper I argue that this is precisely the implication of the emergence of technicians’ work. Although one can point to numerous lines of work that capture an important aspect of the changing division of labor, no candidate for the status of an occupation that is ideal-typical of broad changes in the nature of work in the late twentieth century is more plausible than the technician.

The Technician as a Plausible Ideal Type

Recent cultural recognition. Technician is a relatively recent addition to the language of occupations. Although the term entered English from French early in the nineteenth century, it originally carried no occupational connotations. To be a technician in the nineteenth century was simply to be “skilled in the technique or mechanical part of an art, as music or painting” (Oxford English Dictionary, 1989). Nor was the term particularly flattering: It implied a competent practitioner with no artistic gift. By the early twentieth century, technician had acquired its initial association with work. Most dictionaries of the time defined technicians as people versed in the technical aspects of any subject, including the “practical arts,” a nineteenth-century term for craft. But the modern sense of a technician as a person whose work revolves around instruments and who requires training in a science or technology did not appear in dictionaries until after World War II. The definition from the 1947 edition of Funk and Wagnalls is instructive: “(1) One skilled in the handling of instruments or in the performance of tasks requiring training. (2) A rating in the armed services including those qualified for technical work; also, one having such a rating.”

As the second entry suggests, the military was apparently the first to use technician to refer to a class of occupations. The denotation quickly diffused. By the 1960s references to a military occupational specialty had disappeared from dictionaries, although the number of servicemen and women who held the title increased. The fact that those who compiled dictionaries no longer felt obliged to distinguish between common and military usage suggests that the military’s sense of the term had become colloquial. Thus, the Oxford English Dictionary’s (1989) most recent definition of technician simply reads: “A person qualified in the practical application of one of the sciences or mechanical arts, now esp.: a person whose job it is to carry out practical work in a laboratory or to give assistance with technical equipment.”

Link to a scientific and technological economy. Etymology also shows that technician’s modern meaning is tightly tied
The growth rates were calculated using data from Szafran (1992) and Silvestri and Lucasiewicz (1991).

Growth in technicians’ occupations. The technician’s candidacy for the status of an ideal type is further supported by the growth of technicians’ occupations over the last four decades. In 1950, 1 percent of all employed Americans were technicians (Szafran, 1992). By 1990, the percentage had grown to 3.4 percent, and the Department of Labor has estimated that the percentage will rise to nearly 4 percent by the middle of the next decade (Silvestri and Lucasiewicz, 1991). While technicians, as counted by the government, still constitute one of the smallest occupational categories, their number is hardly insignificant. Technicians outnumber farmers in the U.S., and as of 1990, American firms employed an engineering technician for every two engineers, a science technician for every two scientists, and two health care technicians for every physician. In medical settings, technicians outnumbered registered nurses. The proportion of Americans employed as technicians has grown by 240 percent since mid-century, a rate that dwarfs the expansion of all other occupational clusters charted by the Bureau of Labor Statistics. In comparison, the percentage of Americans employed in service and professional occupations, the categories ranked second and third for growth over the same period, expanded by 89 percent and 82 percent, respectively.

Official statistics on the growth of technicians’ occupations probably underestimate actual growth rates. The government counts as technicians only members of well-known occupations such as radiological technicians and technologists, science technicians, engineering technicians, and medical technicians. Other occupations, such as computer technicians and automobile technicians are grouped beneath the rubric of “precision production, craft and repair occupations.” Computer operators are counted with “administrative support occupations.” More importantly, official occupational categories are blind to trends that are bringing technicians’ work to factories and offices.

The technization of work. Technicians have begun to appear in contexts not traditionally associated with scientific or technical work. Although some firms have simply renamed their employees technicians to counter the threat...
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of unionization (Whalley and Barley, 1996), there is reason to believe that the job title’s growing popularity also indexes substantive change. After a decade of predictions that computer technologies would deskill clerks and factory workers (Braverman, 1973; Glenn and Feldberg, 1979; Crompton and Reid, 1982; Noble, 1984), evidence amassed since the early 1980s suggests that a more prevalent scenario may be the outright elimination (rather than the deskilling) of semi-skilled or unskilled jobs, coupled with the upskilling or reskilling of jobs that remain (Hirschhorn, 1984; Attewell, 1987; Zuboff, 1989; Adler, 1992). This technization of work, as it might be called, appears to proceed along two paths.

The first path is demographic. As firms adopt computational technologies, employment shifts to more highly skilled and often technical occupations. Recent studies of office automation in insurance and banking indicate that the shift is a joint product of two trends: Computers allow firms to employ fewer clerks, but firms must hire more programmers, systems analysts, and computer technicians (Attewell, 1987; Baran, 1987; DiPrete, 1988). Milkman and Pullman (1991) reported similar changes in factories that adopt advanced automation: Unskilled and semi-skilled jobs disappear, while the number of skilled tradespersons and technicians grows. Thus computational systems seem to shift the skill structure of a firm upward by eliminating low-level jobs and by moderately expanding the number of technical and professional employees. The ultimate outcome can be glimpsed in Japan, where firms embraced computer-integrated manufacturing earlier than in the U.S. There one finds assembly plants staffed by an army of robots tended exclusively by a handful of white-coated technicians (Ruzic, 1981).

The second path entails a transformation of existing jobs and relations of production, the reskilling of the workforce. Most evidence for reskilling comes from observational studies in organizations that have acquired advanced manufacturing technologies. Zuboff (1989), who showed that digital control and sensor technologies enable operators in pulp paper mills to monitor and intervene in production processes by analyzing and manipulating representations displayed on computer screens, claims that the technologies have “informated” the operatives’ work. By this she means that their work has become more abstract, more symbolic, more focused on the intricacies of instrumentation, and increasingly distanced from its physical and sensory referents. Others who study computer-integrated manufacturing routinely reach similar conclusions (Hirschhorn, 1984; Majchrzak, 1988; Kern and Schumman, 1992). The scenario is reminiscent of observations made in the 1950s and early 1960s by industrial sociologists who studied continuous process plants, where automated controls were first widely employed and where the term technician was first applied to factory work (Mann and Hoffman, 1960; Blauner, 1964; Faunce, 1965). But informated work does not appear to be confined to those who work in continuous process environments. There is
evidence that advanced computational technologies have made the work of radiological technologists (Barley, 1990), automobile mechanics (Nelsen, 1996b), machinists (Shaiken, 1984), other crafts (Keefe et al., 1992), and even some office workers (Zuboff, 1989; Taitro, 1992) more abstract, more complicated, and in some cases more tightly linked to formal bodies of scientific and technical knowledge. Thus technicians’ work appears to be paradigmatic of broader trends in the workplace.

Transgressing cultural categories. The most convincing reason for treating technicians as a new ideal type may be that they systematically violate our concepts for making social sense of work. Technicians often wear white collars, carry briefcases, and conduct sophisticated scientific and mathematical analyses. Yet they use tools and instruments, work with their hands, make objects, repair equipment, and, from time to time, get dirty. Like those with higher status, technicians have considerable autonomy and are often trusted, though sometimes grudgingly, by their employers (Zabusky and Barley, 1996). With the exception of professionals, technical workers constitute the most highly educated occupational category (Carey and Eck, 1984). Yet, like those in the lower echelons, technical workers are often paid poorly and are accorded low status (Franke and Sobel, 1970; Keefe and Potosky, 1996; Orr, 1996). Technicians thus violate the alignment of those attributes that have long distinguished manual, blue-collar work from mental, white-collar work.

Technicians’ work is no more respectful of existing ideal types. Table 1 situates technicians with respect to attributes that sociologists usually attribute to craftpersons and professionals, ideal-typical occupations that previous researchers have used to make sense of the technician’s role (Evan, 1964; Roberts et al., 1972; Koch, 1977). Technicians resemble professionals in that their work is sufficiently esoteric that few outsiders can claim to possess their skills or knowledge. Their work is relatively analytic and often requires specialized education. Some technicians’ occupations have even developed occupational societies and journals. Yet, in other ways, technicians’ work more closely resembles the crafts. Apprenticeships and on-the-job training play a crucial role in the education of technicians, just as they do in the training of craftpersons (Carey and Eck, 1984), and a significant number of technicians are trained solely through informal apprenticeships (Smith, 1987). Moreover, like craftpersons, most technicians operate equipment, create artifacts, and possess valued manual skills. Outside health care, certification and other forms of control over entry are rare. Finally, like craftpersons, technicians are more likely to unionize than are professionals, a tendency that is especially strong in Europe.

Faced with this unruly blurring of cultural and occupational categories, the few sociologists who have studied technicians have sought to resolve these anomalies by
Table 1

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Professions</th>
<th>Technicians’ Occupations</th>
<th>Crafts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature and distribution of knowledge and skills</td>
<td>Knowledge and skills are esoteric and well guarded. Few outside the occupation have more than a trivial understanding of the content of the occupation’s knowledge base.</td>
<td>Knowledge and skills are esoteric. In some instances, amateurs may exist but, in general, they are rare.</td>
<td>Basic skills and knowledge are widely held by persons outside the occupation, but finesse is less widely distributed.</td>
</tr>
<tr>
<td>Mental/analytic versus manual/sensate work</td>
<td>Tasks are heavily weighted toward mental and analytic work.</td>
<td>Tasks have a heavy mental and analytic component but also a significant manual or sensate skills.</td>
<td>Tasks are heavily weighted toward manual and sensate skills.</td>
</tr>
<tr>
<td>Importance of formal education for training and socialization</td>
<td>Most require either specialized undergraduate or graduate training. Professional societies, licensing, accreditation boards, professional journals are nearly universal.</td>
<td>Many require either a bachelor’s degree or a specialized associate’s degree or its equivalent.</td>
<td>May require a formal apprenticeship; otherwise, formal education is irrelevant. Unionization common but not universal.</td>
</tr>
<tr>
<td>Evidence of formal occupational organization</td>
<td>Professional societies, licensing, accreditation boards, professional journals are nearly universal.</td>
<td>Some technical occupations have journals and professional associations. Others have none.</td>
<td></td>
</tr>
<tr>
<td>Importance of on-the-job training</td>
<td>Informally important but of secondary relevance.</td>
<td>Frequently reported as critical form of training. In some occupations, it is the primary form of training.</td>
<td>The primary avenue by which neophytes enter the occupation.</td>
</tr>
<tr>
<td>Formal certification required to practice</td>
<td>Yes.</td>
<td>Common among technicians’ occupations in medicine. Otherwise, rare.</td>
<td>No.</td>
</tr>
<tr>
<td>Occupational means of controlling entry</td>
<td>High.</td>
<td>Low with exception of technicians’ occupations in medicine.</td>
<td>Low, primarily through union control of apprentice programs.</td>
</tr>
<tr>
<td>Tendency to unionize</td>
<td>Low.</td>
<td>Less common than among crafts, more common than among most professions.</td>
<td>High.</td>
</tr>
</tbody>
</table>

Forcing technicians into one category or the other or by relegating them to the interstices between categories. The first approach was favored by Marxists in the 1960s and 1970s who thought they saw in technicians and other technical workers a challenge to existing class structures. The resolution’s inadequacy quickly surfaced in an extended argument between those who saw technicians as members of a new working class (Mallet, 1975) and those who felt they were a new middle class (Poulantzas, 1978; Gorz, 1982). In the end, the new class debate settled on a mundane compromise: Technicians were an intermediate class (Roberts et al., 1972; Smith, 1987). From the start, locating technicians in the interstices between analytic categories was the preferred solution of American sociologists of occupations. Following Etzioni (1969), some sociologists classified technicians as semiprofessionals, members of occupations that had some but not all of the characteristics of a profession. Others treated them as members of marginal occupations, implying that their work was neither quite a craft nor quite a profession and, hence, that they were subject to status inconsistencies (Evans, 1964; Koch, 1977).

The problem with such resolutions is that they tell us more about the difficulty of discarding traditional analytic
categories than they do about technicians. Rather than take blurred concepts as evidence that technicians are somehow marginal to the existing division of labor, one might argue that the blurring suggests a work role that challenges the utility of existing ways of thinking. Under this hypothesis, if one is to understand technicians’ work and its implications for organizing, one must build a model of technicians’ work based on an understanding of what technicians do. It was to achieve such an understanding that we launched a program of coordinated ethnographies of technicians’ occupations in the fall of 1990.

METHODS

Research Design and Logic

Eight researchers collaborated over a period of five years to produce the ethnographies. Members of the team included a sociologist and an anthropologist with previous field experience, as well as five doctoral students and one undergraduate who were invited to join the project through their involvement in courses on field methods. Traditionally, ethnography has been a solitary affair. Although ethnographers have occasionally collaborated to study the same site (Becker et al., 1961; Strauss et al., 1964), few have attempted to collaborate across settings. For this reason, there are no established guidelines for how ethnographers should pool data, much less coordinate their acquisition. In lieu of using exemplars, we were forced to invent and refine an approach of our own.

The research plan on which we ultimately settled drew inspiration from the logic of a project overlay, a structure commonly used in research and development settings. In an overlay, engineers and scientists come together for a limited time around a specific problem. They draw on each other’s specialized expertise to formulate a solution and then disband, perhaps to join subsequent projects. The structure allows each member to contribute to a team’s inquiry while maintaining his or her substantive expertise. We sought to emulate this structure by becoming experts in particular occupations within the context of a team that could bring individual ethnographers’ expertise to bear on an array of comparative inquiries. Figure 1 depicts the research design as a matrix formed by the intersection of individual ethnographies, on one hand, and comparative analyses of circumscribed topics, on the other.

Ethnographers routinely distinguish between emic and etic analyses. Emic analyses portray a social scene or way of life from the perspective of participants. The telling is usually organized around concepts drawn from the native’s worldview. In contrast, etic analysis draws more heavily on the ethnographer’s perspective, uses the concepts of social science, and aims for a portrayal that is theoretically fruitful. Ethnographers often argue that one cannot pursue emic and etic objectives simultaneously, since they require different approaches to data. What is not widely appreciated is that
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the tradeoff may be an artifact of the tradition of solitary ethnography.

We found that the design in Figure 1 allowed us to pursue emic and etic objectives simultaneously by separating responsibility for the two. The team as a whole took responsibility for comparative, etic analyses, thereby freeing ethnographers to pursue an insider’s understanding of an occupation. We reasoned that it was preferable for each ethnographer to work emically because doing so would insure that any similarities identified across occupations would less likely be artifacts of the team’s agenda. The design for collaborative ethnography depicted in Figure 1 yields two kinds of products: emic ethnographies of individual occupations and etic analyses grounded in the comparison of emic data collected across multiple occupations.

An ideal type is, by definition, an etic idea, an image of a generalized role, but this does not mean that ideal types are necessarily unrelated to the way practitioners understand what they do. In fact, ideal types are likely to be more useful if such connections exist. To ensure connections, we adduced our models of ideal-typical technicians in three steps that began with the ethnographies themselves, moved to first-order comparative analyses, and then to the construction of an ideal type.

Research Flow

Each researcher associated with the project (in one case, a pair of researchers) took responsibility for one or more technicians’ occupations. The ethnographies were conducted in two waves. During the first, researchers chose to study a well-known technician’s occupation on the basis of their

Figure 1. Matrix design for collaborative ethnography.
The latter study (Barley, 1986, 1990) was completed before the research program began. For this reason, the team could not influence the course of the project’s unfolding, but fieldnotes from the study were made available to members of the team and hence were included in the analytic phases of the project.

Bonalyn Nelsen conducted the ethnographies of emergency medical technicians (see Nelsen, 1996a; Nelsen and Barley, 1993b) and automobile mechanics and technicians. Mario Scarselletta studied medical technicians and technologists (Scarselletta, 1996) as well as technicians in factories. Beth Bechky studied science technicians (Barley and Bechky, 1994). Stacia Zabusky and I jointly studied programmers and microcomputer support specialists in two organizations (Zabusky, 1996; Zabusky and Barley, 1996). Asaf Darr (1994) studied customer service engineers and engineering technicians. Christ Inman investigated machinists, and Tim Baynes followed library technicians.

Studies in the second wave extended the range of the research by covering types of work ignored in the first wave. Since the first wave focused on health care and scientific settings, the second included occupations in which computers, machine repair, and engineering played a more prominent role.

Each researcher worked as a traditional ethnographer with respect to the occupations he or she studied. All studies involved six to twelve months of participant observation in one or more sites. On average, researchers logged between two and four days of observation weekly. Researchers rode with emergency medical technicians, stood beside science technicians at their lab benches, diagnosed and repaired computer problems alongside microcomputer support specialists, observed engineering technicians debug hardware, and so on. In the process, each did what all participant observers do: They took copious fieldnotes that they expanded each evening, collected archival materials from their sites, socialized with their informants when off duty, and conducted focused interviews, many of which were taped and later transcribed. By the end of the project we had studied nine technicians’ occupations in depth: emergency medical technicians (EMTs), science technicians, medical technicians, microcomputer support technicians, automobile technicians, programmers, customer service engineers, library technicians, and radiological technologists. But because some of these occupational categories are terms for a number of lines of work, the actual number of occupational groups examined was higher. For instance, radiological technologists included sonographers, computed tomography technicians, x-ray technicians, and special procedures technicians. Similarly, the study of science technicians in biology labs encompassed two different specialties: monoclonal antibodies and flow cytometry. Shorter studies of machinists and technicians in factories were also conducted. Team meetings, held at least once a week for the duration of the project, facilitated collaboration and became the forum for comparative analysis. Early meetings during each wave focused on providing the team with descriptive knowledge of the occupations under study. We devoted each of these meetings to one or more occupations. Prior to a meeting, the ethnographers investigating the occupations to be discussed provided other members of the team with several days of fieldnotes. During the meeting the ethnographers presented a detailed portrait of the occupation’s work as they currently understood it and shared with other members of the team insights or puzzling incidents that had occurred in the field. Team members, in turn, raised empirical and interpretive questions cued by the notes and by the researchers’ presentations. Every occupation became the focus of attention multiple times over the course of the project. The objective was for team members to develop familiarity with the details of practice in the various settings and to provide each other with tips on how to improve their fieldnotes’ comprehensibility for other researchers.

Several months into each wave, as we gained familiarity with each other’s sites and notes, meetings shifted from

2 The latter study (Barley, 1986, 1990) was completed before the research program began. For this reason, the team could not influence the course of the project’s unfolding, but fieldnotes from the study were made available to members of the team and hence were included in the analytic phases of the project.

3 Bonalyn Nelsen conducted the ethnographies of emergency medical technicians (see Nelsen, 1996a; Nelsen and Barley, 1993b) and automobile mechanics and technicians. Mario Scarselletta studied medical technicians and technologists (Scarselletta, 1996) as well as technicians in factories. Beth Bechky studied science technicians (Barley and Bechky, 1994). Stacia Zabusky and I jointly studied programmers and microcomputer support specialists in two organizations (Zabusky, 1996; Zabusky and Barley, 1996). Asaf Darr (1994) studied customer service engineers and engineering technicians. Christ Inman investigated machinists, and Tim Baynes followed library technicians.
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imparting descriptive knowledge to examining topics pertinent to all occupations under study. Representative topics included the following: uncertainty in technicians’ work, the role of instrumentation, relations with coworkers, clients, and supervisors, and the technicians’ definitions of good and bad practice. At this point, comparative analysis began. Once the team identified a potentially fruitful topic, members culled from their notes all passages that seemed relevant to the topic and then annotated the passages to provide sufficient information for others to understand the context in which the events occurred. Each ethnographer duplicated and distributed the annotated passages. Team members read the annotated passages and developed potential coding schemes. Once everyone had processed the passages, the team met as a whole to discuss them.

The objective now became joint analysis and the production of analytic memos that detailed commonalities and differences across occupations with respect to the topic at hand. The investigation of a topic always spanned multiple meetings and involved iterative coding and analysis. After joint discussions, team members reread and recoded passages prior to the next meeting, using codes on which the team had agreed. The objective was to develop an ever more refined framework for rendering the data. For instance, when examining the role of uncertainty in technicians’ work we initially focused on identifying types of uncertainty, the coding of which led to the realization that types of uncertainty varied across settings. We then turned from analyzing types of uncertainty to identifying sources of uncertainty, consequences of uncertainty, and strategies for managing uncertainty, which led to an analysis of types of contextual knowledge. The end product was a series of analytic documents that detailed a mini-theory of uncertainty and contextual knowledge in technicians’ work.

Joint coding and analysis also enabled researchers to identify potential holes in each other’s data. In response, ethnographers adjusted their observational strategy to ensure that they had not simply overlooked data relevant to the comparative analysis. The upshot was that we gradually agreed on a set of phenomena on which all would attempt to gather data. These included tales of informants’ careers, descriptions of technologies and how they were used, interactions between technicians and other people in the work setting, the paths by which technicians acquired technical information, and so on. Coordinated data collection thus arose from an evolving understanding of what was important in technicians’ work, rather than from preconceived notions of what might be important.

The comparative analyses and analytic memos provided a platform for moving to the more general typification of technicians’ work presented below. Since ideal types gloss practices and positions, we approached the task as a form of role analysis. All roles have nonrelational and relational elements (Nadel, 1957). The nonrelational elements of a work role are the set of recurrent activities that fall within the purview of a job, the most important of which are tasks and techniques. The relational aspects of a role are defined by routine, patterned interactions between role incumbents.
and members of other positions: the interactional logic of a role set.

To execute the role analysis we first sought to specify the general structure of the nonrelational elements of the technicians’ work. We then examined how these nonrelational elements entangled technicians in a web of role relationships. The first allowed us to characterize the substance of technicians’ work, while the latter enabled us to specify how technicians’ work fit in a division of labor. We began by subjecting our analytic memos to the same sort of scrutiny that we had used with our fieldnotes. We proposed models on the basis of the first-order analyses and then checked and refined them against the data themselves. We deleted aspects of proposed models that did not subsume the work of all occupations or lead to cogent distinctions among occupations.

As a final check on the adequacy of our analysis, we distributed working papers detailing our models to our informants and other groups of technicians for evaluation. In all cases, the analysis met with excited approval. Most telling was that no technician told us that he or she had learned anything new from our documents. Instead, they said we had presented what they already knew, albeit more systematically than they would have done. We take this as evidence that what follows is a viable image of the general role that technicians play in late-twentieth-century organizations.

WHAT DO TECHNICIANS DO?

The Nonrelational Core of Technicians’ Work: Managing the Empirical Interface

Most occupations have historically revolved around the manipulation of things, symbols, or people. Work focused on things has traditionally entailed little responsibility for symbols or people, and vice versa. In many systems of production, however, material and symbolic work cannot be completely segregated. When important symbols represent material phenomena, symbolic work will lack accuracy unless the symbolic and the material are linked. The core of technicians’ work lies in creating these linkages.

Although the substance of technicians’ work varied widely across the occupations we studied, we found that all technicians worked at an empirical interface: a point at which a production system met the vagaries of the material world. Using sophisticated instruments, techniques, and bodies of knowledge, technicians stood with one foot in the material world and the other in a world of representations. Depending on the occupation, the material entities were computers, software, microorganisms, the human body, a manufacturing technology, or another mechanical system. Similarly, depending on occupation, relevant representations consisted of data, test results, images, or diagnoses. As Figure 2 indicates, bridging the material and the representational pivoted around two complementary processes, transformation and caretaking.

4 The classification of work according to whether it focuses on things, symbols, or people has a long history in the sociology of work, perhaps because the Dictionary of Occupational Titles rates occupations on these foci and because DOT data have been widely used by students of work and occupations.
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Figure 2. The nonrelational aspects of technicians’ work: The empirical interface.

<table>
<thead>
<tr>
<th>Material Entities</th>
<th>Empirical Interface</th>
<th>Representations</th>
</tr>
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<tbody>
<tr>
<td>Biological Systems</td>
<td>Technologies</td>
<td>Data</td>
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<tr>
<td>Physical Systems</td>
<td>Techniques</td>
<td>Test Results</td>
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<tr>
<td>Mechanical Systems</td>
<td>Knowledge</td>
<td>Images</td>
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<td></td>
<td></td>
<td>Diagnoses</td>
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Technicians employed technologies, techniques, and the knowledge at their disposal to transform material entities into signs, symbols, and indices. Medical technicians used clinical analyzers, microtomes, microscopes, and other instruments to produce counts, assays, and descriptions of tissue samples. Science technicians used an array of instruments and protocols to reduce physical and biological phenomena to data and charts. Automotive and factory technicians used oscilloscopes, computers, and software to create representations of an engine’s or a production system’s functioning. Yet technicians did more than simply generate signs: They were also responsible for taking care of the entities from which they coaxed information. In one way or another, all technicians were charged with ensuring that machines, organisms, patients, and other physical systems remained intact and in good working order. Caretaking almost always required that technicians employ the representations they created. Thus emergency medical technicians performed interventions, such as defibrillation or intubation, based on their interpretation of data they generated at the site of an accident. Customer service engineers used the results of tests and probes to alter the functioning of the hardware their company sold. Medical technicians used the results of assays to monitor the adequacy of their samples, the alignment of machines, and the procedures that others had used to collect the samples.

A sense for how integral transformation and caretaking were to technicians’ work can be gleaned from a routine incident drawn from fieldnotes from the study of microcomputer support. On this occasion, the technician was summoned to investigate a personal computer whose owner reported that she could no longer access MSMail, a program located on the network’s server. The excerpt begins as the technician (Sudesh) seats himself at the computer:

Sudesh explained to the user’s secretary, who stood beside us, that one possibility for the problem’s sudden appearance was that critical files on the hard disk had become corrupt. To determine whether this was true, he inserted a copy of Norton Utilities into the computer’s floppy drive and scanned the user’s directories for corrupted files. After several minutes, the program reported it had detected no corrupted files (transformation). Sudesh now tried to start MSMail, but error messages told him that he couldn’t get in (transformation). Sudesh wondered if the user had altered the code in her autoexec.bat and config.sys files that enabled her to access MSMail. He brought the files into an editor and discovered that the
In the remainder of this paper, "professional" refers to members of occupations for whom buffers produced representations. This use improves readability. It is not meant to attribute or deny attributes to technicians or to members of any other occupation and should not be read as a judgment of an occupation’s value.

In this example, the material entity is the computer, and the representations consist of data and indices created by diagnostic programs or the computer itself in response to the technician’s probes. Sudesh used programs and his general knowledge of computers to act on this computer in ways that generated signs and symbols (transformation) that suggested, confirmed, or disconfirmed hypotheses and that directed his subsequent actions with respect to the computer (caretaking). Transformation and caretaking thus enveloped the technician and the computer in a spiraling relationship. It was precisely this sort of cybernetic encounter with the material world, mediated by technologies and techniques, that characterized all technicians’ work. For technicians, the process was mundane, but for others, like the secretary in this incident, it appeared mysteriously skilled.

The Relational Logic of Technicians’ Work

Transformation and caretaking at an empirical interface highlight the core of technicians’ work: They are what makes technicians’ work technical. But to understand technicians’ roles fully, one must also consider the social meaning of their work, which rested on how they were situated in a local division of labor. Whereas the nonrelational structure of technicians’ work was constant across all occupations we studied, we found that technicians were positioned in organizations in two different ways: as what we call buffers and brokers.

Buffers. Some technicians sat at the start of a serially interdependent (Thompson, 1967), occupational division of labor. The representations they generated became input for the work of another occupation, usually one that sociologists consider a profession. Science technicians, engineering technicians in R&D labs, radiological technologists, emergency medical technicians, and medical technologists were of this sort. These technicians worked closely with scientists, engineers, or physicians to provide information from which the latter constructed theories, designs, and diagnoses. But these technicians did much more than produce data: They buffered the professionals who used the data from the very empirical phenomena over which the latter were reputed to have mastery. For instance, because science technicians operated lab equipment and conducted experiments, it was they, rather than the scientists, who

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presided over a lab’s encounters with the physical world. Thus the scientists did not have to concern themselves with the practical uncertainties of empiricism. By stabilizing patients at the scene of an accident, emergency medical technicians relieved physicians and nurses of the need to do triage. Radiological technologists and medical technicians, respectively, distanced radiologists and pathologists from patients or their bodily tissues and fluids.

Figure 3 summarizes the buffer’s position. The flow of production moves from left to right, with the technician first reducing physical phenomena to representations and then conveying those representations to a professional, who operates on the representations to synthesize a more complex symbolic product. The figure highlights several critical points about the buffer’s position. First, because buffers linked the material world to a symbolic world, they were responsible for ensuring referential meaning. Their practices and skills determined the quality of the correspondence between signs and what the signs presumably signified. Second, buffers and professionals shared a social world, whether it was the world of a medical specialty, the world of a scientific discipline, or another substantive domain. Thus they were members of the same speech community. For this reason, buffers could transmit the representations they created directly to a professional without translation. Emergency room physicians often used the EMT’s initial assessments to begin treatment. Radiologists often dictated diagnoses based entirely on a sonographer’s images and interpretations. Scientists frequently incorporated data assembled by technicians, without further analysis, into arguments, papers, grants, and theories. The more faith professionals had in the referential quality of the technician’s representations, the more likely they were to accept the technician’s data without question.
Membership in a common speech community underwrote a third characteristic of the buffer’s work. Buffers routinely appropriated the professionals’ theories, plans, diagnoses, or designs to guide their own work at the empirical interface. To stabilize patients, EMTs had to render assessments that, in turn, required them to be conversant with theories of disease. To troubleshoot prototypes, engineering technicians had to read and understand the engineer’s schematics and calculations. By drawing on elements of scientific theory, technicians in biology labs puzzled through the enigmas that inevitably arose during experimental procedures. To capture diagnostically useful information, sonographers had to understand pathological processes.

Brokers. In contrast, joint membership in a social world was uncharacteristic of the work of computer technicians, programmers, network administrators, factory technicians, and others who built, repaired, and monitored complex technical systems. The representations that these technicians created were not substantively relevant to other people’s work, and their expertise differed radically from that of the people they served. For this reason, unless the technicians worked in an organization specializing in repair, they often perceived themselves to be, and were seen by others as foreigners in the work site.

Technicians of this sort were primarily responsible for creating or maintaining the technical infrastructures that enabled other people to do their work. Because members of other occupations did not depend on the representations the technicians created, but on the systems they maintained, the division of labor was neither serially nor occupationally interdependent. Instead, the technicians worked in what might be called a commensual, organizational division of labor. Work relationships between the technicians and those whom they served were symbiotic: The technicians created affordances for other people’s work, and vice versa. Although these technicians insulated the users of a technology from the technology itself, their role was more accurately that of a broker.

Figure 4. Broker technicians.
The term cutpoint is drawn from graph theory, where it refers to a point that, if removed, disconnects an otherwise connected graph.

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Figure 4 illustrates the logic of a broker’s position. Brokers bridged two communities: the users they served (either permanently or temporarily) and the technical community associated with the technology for which they were responsible. The work entailed adapting the technical community’s knowledge and products to the contextually specific needs of users, clients, or customers. Microcomputer technicians and in-house programmers, for instance, were charged with assembling, modifying, and repairing workstations, networks, and databases used by an organization’s employees. To do so, they continually scanned the technical community for relevant information and technologies while simultaneously communicating with users about the organization’s needs. The systems that computer technicians constructed were local syntheses of the constraints and possibilities defined by the intersection of the two worlds. Brokers adapted technological feasibilities to local realities.

The broker’s relationship with a community of users pivoted on two processes. On one hand, brokers had to assess the users’ needs to develop systems that met those needs. On the other hand, brokers also had to educate users about the system’s functioning, features, and limitations, if the system was to perform optimally. But because brokers and users inhabited different social worlds, the technicians’ mission required that they be able to restate technical information in a form that users could comprehend. Thus brokers had to engage in considerable translation. Users’ needs had to be formulated as technical parameters, and technical parameters had to be made meaningful to people with little technical background. Unlike buffers, brokers had to speak the language of two communities.

While the brokers’ relationship with the technical community resembled that of a buffer in that they usually identified with the technical community and spoke the same language, their relations with members of the technical community were more sporadic and distanced than that of a buffer. For instance, the technical community relevant to microcomputer support was populated by vendors of hardware, software, and technical services. Technicians monitored the community for state-of-the-art information and solutions to actual or potential problems. They read the technical community’s literature and consulted with other technicians and vendors when opportunities arose. They also provided the technical community with feedback when reporting bugs or when consulting with vendors about unanticipated interactions between a product and the system in which it had become a component. Automotive technicians provided similar types of intelligence to automobile manufacturers. But, like users, members of the technical community could do their work without the representations that brokers created.

Although buffers and brokers were immersed in substantially different divisions of labor, their positions were similar in at least one crucial respect. Both buffers and brokers were “cutpoints” in a production system, much like the mechanics that Crozier (1964) observed. Buffers mediated and controlled the processes that produced the data that
professionals needed for their own work. Brokers linked a community of users to technologies on which they depended and to the technical community that produced the technologies. Thus the organizations in which both kinds of technicians worked were vulnerable to their loss. To understand why this vulnerability was more than a structural possibility requires an appreciation of what technicians had to know to span an empirical interface.

WHAT DO TECHNICIANS KNOW?

Formal Knowledge

Educators and sociologists often conceive of technicians as junior professionals, workers who know some proper subset of what a professional knows (Owen, 1984; Hull, 1986). For this reason, schools that train technicians usually require courses in math, science, and engineering similar to those taught in professional schools. Some technicians in our studies clearly benefited from knowing scientific and technical theory. For instance, science technicians found their formal coursework helpful for reading the literature in their field and for thinking about why physical phenomena did not always respond as protocols predicted. Programmers drew on techniques they learned in computer science classes when writing code. EMTs and medical technologists required knowledge of biological systems, pharmacology, and disease processes to render diagnostically useful information. Microcomputer support technicians required a schematic understanding of how computers and software function. Yet, in the course of a day’s work, formal knowledge was less important than educators and hiring policies often suggested.

Except in medical settings, where degrees were mandated by law, we encountered many technicians who had no formal training whatsoever. Even in science and engineering labs, where credentials were customary, a quarter of the technicians had no more than a high school diploma. Over half of the computer technicians and programmers we studied had never taken courses in computer science. Many had degrees in the humanities or the social sciences, and a few had never been to college. Even more telling was the fact that almost every technician with whom we spoke devalued credentials. Comments by a computer technician and a sonographer were representative:

What do I use from my schooling? Well, the typing class I took was pretty good. From my computer classes, not too much. A little bit from the system design course. But in my second year [at college] I became a computer proctor. I watched over the computer lab and got to be good friends with the man in charge of tech support for the campus. So my job actually moved into working with him instead of being a proctor in the computer room. He and I would go around campus fixing and upgrading computers and running cable. So that’s where I got all my background. (Microcomputer support technician)

On the registry [an examination for certifying sonographers] they want to know such things as "what kind of tissue is the pancreas composed of?" How the hell do I know and what difference does it make? Pancreatic tissue! I’ll go one-on-one with anybody in scanning ability . . . I know my way around the body three
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dimensionally. . . . That's not easy and most kids coming out of the programs can't do that. . . . A lot are coming out incompetent. We had a student out here. She could sit down and go through charts and read pathology reports and tell you what they meant. . . . She could draw you a picture of the vascular system, but she couldn't find it in the body. They're just not properly trained. Experience is the best teacher. . . . (Sonographer)

Contextual Knowledge

Technicians valued experience over formal training, in part, because technologies and techniques changed so quickly that by the time they filtered into the classroom they were already outdated. Moreover, knowledge became relevant in practice only in light of the problem at hand. But since, almost by definition, problems involved unanticipated troubles, technicians found they had to piece together most of the information necessary for resolution from the situation itself. Under such conditions, the utility of formal training appeared remote. In fact, most technicians claimed that a technical education was primarily useful for learning a more disciplined approach to solving problems. The substantive knowledge that proved most critical came from neither courses nor books, but from doing. Thus, by experience technicians did not simply mean years of practice. Instead, they meant a situated, rather than a principled knowledge of materials, technologies, and techniques. It was this contextual knowledge that made their contribution unique. Although the skills, abilities, and bits of information that made up contextual knowledge varied widely across occupations, broad commonalities existed.

Semiotic knowledge. Critical to all technicians’ work was semiotic knowledge, the ability to make sense of subtle differences in the appearance of materials and the behavior of machines. Accomplished technicians saw signs and codes where novices, and even professionals, saw no information at all. For instance, bench talk in science and pathology labs revolved around the relevance of colors, shapes, and smells. As the following interaction between experienced and inexperienced monoclonal technicians attests, training typically involved teaching new technicians to recognize and interpret minute differences in sensation:

[Sally and Mary took turns peering through a microscope.] Sally asked Mary to look at the cells. As Mary peered into the microscope, Sally . . . assured her that the first time she looked at the results of a fusion she thought it hadn’t worked. “But,” she continued, “you can see that there are some live colonies beneath the dead cells.” Sally called Mary’s attention to a well in which the medium had turned dark yellow, a sign that it probably contained many hybridomas. As Mary examined the well, Sally noted that the “stretched out” cells on the bottom were fibroblasts. Mary asked how you could tell if a cell was a hybrid. Sally responded that if it wasn’t, it would eventually die and dead cells “look dark and grainy.” She continued, “the groups of round cells are the hybrid colony. . . .”

Most other technicians also relied heavily on patterns and sensory cues. When overhauling automatic transmissions, automotive technicians used both sight and smell to detect unusual patterns of scoring and the decomposition of lubricating fluids that denote excessive wear of parts. Sonographers distinguished between findings and artifacts.
by noting subtle differences in the shading of images and by attending to other indices, such as the presence of scars on a patient’s body. Microcomputer technicians sometimes identified problems by attending to the sequence in which error messages occurred rather than the messages’ denotations.

**Sensory-motor skills.** Sensory-motor skills were a second component of contextual knowledge. Technicians often spoke of “having a feel” for instruments, materials, and techniques. Although the idiom was at times synonymous with familiarity, in most instances technicians used the phrase to refer to tactile skills, what Harper (1987) called “ways of the hand.” Cell culture specialists, for instance, claimed that developing a feel for pipetting was critical because too heavy or too light a touch could destroy the cells that the technician had so carefully cultured. To diagnose an engine problem, automotive technicians initially engaged in “purposeful groping”—running fingertips along vacuum hoses and tugging lightly at wires and connectors—to eliminate simple sources of mechanical and electrical failure before turning to more complex diagnostic procedures. EMTs gained reputations among their peers for the dexterity with which they inserted intravenous needles or tracheal tubes. Knowing how to rotate a transducer deftly against a patient’s skin to obtain images of organs from various angles was integral to successful practice as a sonographer.

**Heuristics.** Contextual knowledge also encompassed an encyclopedia of heuristics or rules of thumb derived from experience and reading. Heuristics encoded bits of knowledge about particular instruments, materials, or procedures and were rarely written down. They circulated among technicians as stories or snippets of advice. For instance, when routine procedures failed to reveal the presence of a gallstone in patients with appropriate symptoms, sonographers knew that they could usually make stones appear to “drop” across the ultrasound’s monitor by having the patient roll to one side. Computer technicians always checked configuration files on malfunctioning computers because users regularly and unwittingly altered these files when installing new software. Because temperature was known to affect the metabolism of cells and the properties of reagents, monoclonal technicians kept hybridomas in a tray of ice to slow their metabolism and guard against changes in pH unrelated to processes under study. Such tricks of the trade often made the difference between successful and unsuccessful practice.

**Adherence to a work style.** Being a technician entailed knowing how to minimize uncertainty and guard against mistakes common at a particular empirical interface. This knowledge almost always led to a distinct style of practice that technicians explicitly taught to novices and by which they identified master practitioners. Although workstyles varied by occupation, all consisted of behaviors and demeanors with the moral force of a code of conduct. For example, emergency medical technicians worked in unfamiliar, chaotic, and even dangerous situations. To do triage in such environments, EMTs often had to manage
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distraught family members, meddlesome spectators,
life-threatening hazards (such as fire), and even unruly
crowds. The ability to project an improvisational, coolly
detached, decisive demeanor, even when frightened and
confused, was critical to EMTs. Full-time EMTs, in particular,
learned to speak quickly and with authority, to coordinate
their work with glances and gestures, and to present
themselves with the bearing of police, an act greatly
facilitated by short, precisely cut hair, paramilitary uniforms,
and black, leather-holstered belts.

In contrast, the greatest danger in molecular biology labs
was the contamination of cell cultures and the tendency to
forget what one had already done. To guard against
contamination, cell culture technicians adhered compulsively
to rituals of cleanliness. They routinely sterilized all
glassware, doused countertops with disinfectants, worked
with cells only under a flow hood that filtered the air, shed
the lab coats they wore elsewhere before entering the clean
room, and frequently replaced pipette tips even when it was
not technically necessary. To counteract forgetting, lab
technicians meticulously recorded every action (often in
copylicate and triplicate) in notebooks and on forms. In fact,
science technicians were constantly inventing new forms
and ways of logging information. Technicians and scientists
who compromised such practices were said to be
“unscientific.”

Local idiosyncrasies. Work at an empirical interface also
demanded knowledge of local idiosyncrasies. Precisely how
a technician performed a task depended, in part, on the
specific materials, instruments, and techniques used at a
site. Even in the same biology lab, cell lines that were
nominally similar often responded differently to the same
protocol. Thus monoclonal technicians had to know when to
adapt their practices to the lineage of a particular cell culture.
The performance of functionally similar computer systems
was strongly influenced by the components from which they
were constructed. Network cards built by different vendors
behaved differently, and previous decisions, such as how to
write a piece of code or connect a series of servers, strongly
affected the way programmers and technicians had to think
about subsequent problems. Local histories of decisions,
problems, and fixes, as well as the idiosyncrasies of local
materials and instruments, created a web of constraints and
affordances that no theory could predict (see Pentland’s
1992, 1996 work on hotline support technicians, for similar
observations). Without knowledge of such particulars, even
otherwise experienced technicians could be rendered
helpless.

Access to distributed knowledge. Of course, no technician
was the master of all relevant heuristics and local
idiosyncrasies. Similarly, some technicians had better
sensory-motor or semiotic skills than others. It was common
for some technicians to have encountered problems that
others, at best, had only heard or read about. In short, the
knowledge that enabled effective practice was distributed
among technicians. Technicians were well aware of the
distributed nature of contextual knowledge. As Orr (1996)
found in his study of photocopier repair technicians, knowing
the subculture’s rules for accessing distributed expertise was also part of knowing how to resolve problems at an empirical interface.

In the pathology labs we studied, medical technicians worked at lab benches in close proximity to each other. When running tests or inspecting tissue samples, the technicians expected each other to announce puzzling results publicly. Announcements often occasioned lengthy and spirited conversations in which technicians recalled instances in which they had encountered similar findings and offered hypotheses about why such results might occur. Participation was governed by strict sanctions. Those who masked ignorance or confusion, and were subsequently found to have made a mistake, risked public humiliation:

Karen [said] that the error . . . which had resulted in a reprimand from the chief pathologist, had been traced to Emily. . . . The case . . . involved the failure to identify cells in a spinal fluid that were clearly abnormal. In response to this error, Karen had retrieved the original sample and had shown it to some techs on the 3rd shift. Eventually it ended up on the main table in hematology, where techs on all shifts took turns inspecting it. Apparently this upset Emily tremendously. She told Karen that she was making her “look bad.” But Karen expressed no remorse for her actions, noting that “people get really embarrassed if they don’t know something—they don’t like to admit that they don’t know what something is. . . . But that’s nothing to be ashamed of. The mistake is in not asking questions or trying to find out more if you’re not sure what it is.”

The microcomputer technicians we studied briefed each other daily on the work they had done and the problems they had encountered. Technicians who faced perplexing problems were expected to ask for help and to subject themselves to a technical version of “20 questions,” a game structured much like a quiz: “Did you check the configuration files?” “Did you remember to install the HP driver?” “Have you considered the possibility of a bad memory chip?” Questions often pertained to what technicians considered obvious possibilities and could be read as implying that the questioner had greater knowledge. To the uninitiated or insecure, such questioning could be threatening, as it was for some users who were also routinely quizzed in the process of diagnosis. Yet computer technicians took no affront, because they viewed pointed questioning as a conduit for tapping distributed expertise.

In some sites, we even found technicians who had developed mechanisms for accessing the knowledge of technicians in other organizations. Medical technologists from several hospitals in a city where we conducted interviews had established an informal network that met once a month to discuss lab problems. Science technicians routinely consulted technicians working in other labs when they encountered puzzling events. Computer technicians met formally and informally with technicians from other organizations to discuss problems and recent technical developments. Several computer technicians had even begun to use the Internet to tap the expertise of technicians they had never met. The distributed nature of contextual knowledge led technicians to form communities of practice (Lave and Wenger, 1991) that sometimes extended beyond their worksite and that had the potential for evolving into
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full-scale occupational communities (Van Maanen and Barley, 1984).

Reconsidering the Distribution of Substantive Knowledge

Recognizing that contextual knowledge was largely what enabled technicians to manage an empirical interface challenges traditional views of a technician’s expertise. Our data are inconsistent with the view that a technician’s knowledge is a proper subset of what another occupation knows. In the case of buffers, a more accurate image would be that of intersecting sets. Buffers and the professionals with whom they worked shared a pool of knowledge. Technicians were familiar with the scientific or technical principles that informed the professional’s training and expertise. Conversely, scientists, engineers, pathologists, and radiologists could, if necessary, stand in for technicians. Technicians even considered some to be quite competent. Yet the professional’s knowledge of materials, technologies, and techniques was skewed toward a principled understanding, while the technician’s was weighted toward the contextual.

Traditional images of what technicians know are even less adequate for brokers. Although brokers sometimes encountered technically adroit users—the car or computer buff—most knew little about the technologies that brokers maintained. A running source of amusement for automobile, engineering, and computer technicians were users who feigned knowledge but revealed profound ignorance despite their air of certainty. What brokers and users knew often approximated disjoint sets. Although the broker’s knowledge did overlap with that of certain members of the technical community, even here the relationship was more like that of a buffer than a junior professional.

The fact that technicians were masters of contextual knowledge also explains why their positions as cutpoints engendered significant dependence. The contextual knowledge necessary for working at an empirical interface resided largely within the technicians’ community of practice. At best, outsiders had but partial knowledge of how the interface worked. Because substantive knowledge was unevenly distributed, the systems of production in which technicians participated would have been crippled by their absence. The problem was especially acute in the case of tightly coupled technologies, such as networked computers and integrated manufacturing, where a problem in a single component could easily bring an entire workplace to a standstill.

ORGANIZATIONS’ RESPONSES TO TECHNICIANS: SERVANTS OR EXPERTS?

Most professionals and users were well aware that they depended on technicians. Some openly admitted and even accepted their dependence. Radiologists, for instance, were often quite candid about the fact that they relied heavily on sonographers’ interpretations of films. Dependence was particularly strong among older radiologists, who were generally less skilled than their younger colleagues at reading ultrasound images. Seasoned scientists admitted
that without technicians, lab work would stop, because they did not themselves possess the contextual knowledge necessary for working at the bench. In fact, graduate students and postdoctoral fellows in the molecular biology labs we studied learned empirical procedures largely from technicians. The comments of the director of a monoclonal lab were remarkable only for their candor:

I did tissue culture for six years and was pretty good at it. Fifteen years ago, I knew the state of the art. But now, I don’t know what they are using to wipe down the incubator. I have no hands-on knowledge of the cells. [Our research support specialist] can tell immediately if the cells are happy, from all the hours she spends looking at them. This is where the art comes in. It isn’t mystery or mysticism, just the things that you don’t consciously know—they are at the edge of your consciousness. Subtle things. A tech will say, “this doesn’t look quite right.” No one ever tells you these things, they aren’t written down in books. . . . I have seen lab directors ruin their lab by giving orders to an RSS [research support specialist] or a tech who should be an RSS. A month later, the tech is looking for a new job and the director is left holding the bag.

Others, however, spoke more grudgingly of their dependence. Secretaries, administrators, and faculty who relied on computer technicians to keep their workstations and networks running often complained that even the best technicians were slow to respond, that they did not appreciate the troubles that downtime caused, and that they made users feel stupid:

I think they’re very nice young men, but I don’t think they’re too attentive to our problems. I’m sure you know when your computer breaks down and you’re in the middle of a rush job, you don’t want to sit a day and a half. . . . They don’t return calls. But I know they get the messages because they get to you eventually. . . . They could call and say, “I’m really busy and I can’t get there until 2 o’clock.” But they don’t. . . . They do try to teach us how to do things. Last week one of the secretaries down the hall got a new Windows program and she got them to come up and help her. But I think she told me that they didn’t know much more about it than she did. (Secretary)

Professionals and users who resented their dependence tended to treat technicians ambivalently. The ambivalence surfaced in the dilemma over whether technicians were servants or experts. Members of the technicians’ role set often portrayed them as insufficiently servile servants. This was particularly true when systems were functioning properly. During interviews, most computer users implied that computer technicians should be handy helpers who appeared on a moment’s notice, resolved problems without delay, and disappeared as quickly as they came. The following excerpt from an interview with a technically competent computer user provides a sense for what most users desired:

We make our living with computers. Without a computer I couldn’t do anything. I embraced computers long ago and until we got this network my view was, “get me a computer and leave me alone.” I knew how to maintain my own. I had no interest in having anyone come and mess around with my machine because I had it set up the way I wanted. When the network came in, all that changed. . . . It’s very frustrating because if the computer’s broken, I sit here because there’s nothing I can do. I have no idea of what’s going

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on What I want out of support is simple: make my machine work and leave me alone. (Economist)

The perception that technicians should be well behaved, responsive, and complacent was not confined to computer repair. Automobile owners regularly expected instantaneous, undivided attention from automotive technicians who, they insinuated, were often less than honest about the repairs that were required. Radiological technologists and medical technicians spoke of the need to tread lightly on doctors’ egos with their own expertise. As a sonographer in training put it: “The thing that makes me nervous is to scan a patient and then tell the radiologist what you think you see. You have to know what you’re doing without coming across like you think you’re a doctor.”

Yet at critical junctures in their daily work and especially in situations of crisis, professionals and users had little choice but to abdicate to technicians. For example, a new post-doc assigned to a monoclonal lab disregarded a technician’s advice on how to perform fusions and flagrantly violated the technician’s preferred style of work. In retaliation, the technician allowed the post-doc to proceed precisely as he wished. As the technician predicted, the fusion failed. When the post-doc approached the technician for help, she made it clear that she would assist only if he did as she instructed. The post-doc complained about her “attitude” to the director of the lab, who told him that the technician knew what she was doing. With no other recourse, the post-doc reluctantly complied with the technician’s directives, and the fusion worked.

Similarly, radiologists who had not been trained on computerized imaging technologies, like ultrasound and CT, frequently found themselves consulting and even being taught by technicians. Even those computer users who complained most bitterly about the technicians’ lack of responsiveness knew they had little choice but to stand obsequiously to one side when their computers malfunctioned. Perhaps it was for this reason that few users voiced their complaints directly to technicians. In the case of high-status users, the technician’s arrival often entailed a sort of role reversal in which the user became, for the moment, subservient. The following instance in which a prestigious professor became the technician’s student was common:

We had taken only a few steps down the hallway, when Professor Jones came out of his office and asked if Allen would help with a problem. Jones explained that he had seen Allen go to the office across the hall and had been waiting for him. Allen agreed. Jones had apparently interrupted a meeting to snag Allen because two other faculty were seated in chairs beside his desk. Ignoring them, Jones accompanied Allen to the computer. Jones explained that he had tried to send email to another faculty member but couldn’t do it. Allen explained that this was not surprising, since the new faculty member hadn’t been given an email address and wouldn’t be on Jones’s nickname list [which computer support provided to all users]. Jones then admitted that he couldn’t even find his list. Allen entered the mail program and found the list. The user was simply not noticing that the menu had an arrow beside the title “Main” which, if clicked, would reveal a pull down menu listing the lists that Jones claimed he couldn’t find. Jones thanked Allen and
then said sheepishly, "Can I ask you another question?" "Sure," Allen replied. "How do I throw things out?" by which he meant, delete old mail files. Allen showed Jones how to delete the files. Jones thanked Allen saying, "I appreciate your help, I just have trouble understanding."

Ambivalence about whether technicians were servants or experts was not simply a theme of daily interaction, it suffused organizational policies as well. In some cases, the ambiguity was encoded in the titles that technicians held. The most well-trained EMTs were formally known as "paramedics," literally "subsidiary to medics." The computer and science technicians we observed were called "microcomputer support specialists" and "research support specialists," respectively. The term support intimated that the technicians were hired to assist others; the term specialist acknowledged they knew how to solve problems that others did not have a clue how to solve for themselves.

Ambivalence also characterized employment policies. Many organizations we studied formally required candidates for technicians’ positions to possess degrees or certificates in a technical field. For instance, personnel managers claimed that science technicians had to have at least a bachelor’s and preferably a master’s degree. In reality, however, scientists were often willing to violate the personnel office’s rule to acquire a skilled technician. Hospitals would not hire medical technicians or radiological technologists unless they were certified, and to be certified one had to possess at least an associate’s degree in the field. Yet many employers were unwilling to pay a premium for advanced degrees. In upstate New York, where we conducted our research, starting salaries for medical technicians and engineering technicians with associate’s degrees averaged $22,000 per year at the time of our study. Except for the most senior science and engineering technicians, none of the technicians we encountered made over $30,000 a year.

As one might expect, almost every technician complained about low wages. Technicians certainly wanted more money for instrumental reasons, but their most common complaint was that low pay indicated that their employers did not truly respect their expertise. As one radiological technologist remarked one day after reading a newspaper article on a lottery winner, “If I won the lottery, I’d tell everyone who ever treated me with disdain to fuck off.” Low pay was simply the most constant reminder that technicians lacked the respect they believed they deserved. Other reminders were more sporadic, but far less ambiguous. A pathologist in command of a hospital laboratory, for instance, noted that although medical technicians held degrees and had their own journals, he considered their journals "throwaways," because “when I get them I throw them away.” A financial administrator with no computer background but who was in charge of a group of computer technicians expressed similar disdain. During an interview the administrator remarked that “compliance problems” were endemic among “computer people.” “They consider themselves to be professionals,” he commented, “but they don’t have the requisite capacity for judgment.” Of course, managers and administrators rarely voiced such opinions quite so boldly around the
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Technicians themselves. Nevertheless, technicians inferred the message from behaviors and situations. Every emergency medical technician had stories about emergency room nurses and doctors who treated them like “ambulance drivers.” Medical technicians and radiological technologists spoke of physicians whose notions of servitude extended to a willingness to take abuse. We observed one such occasion:

Joe was re-running a spec several times and I observed aloud I hadn’t seen so many checks for accuracy before. Joe explained that he was manually rechecking a result he had earlier produced on the machine. Even though the result was correct, the physician had rejected it. “This doctor that I’m dealing with here can get real irate,” Joe said. “When this initially happened, the doctor looked at my results and actually called down here and said, ‘You’re full of shit—where’s the real result!’ He was all over me like a cheap suit, which I thought was unprofessional. I ended up getting a QA [written reprimand] even though the result was correct. So I want to be sure that I’ve done everything I can this time to show the results are right.”

The referring physician continued to dispute the data until a pathologist finally confirmed that the technician’s results were accurate and told the physician that he should reconsider his assessment of the patient’s condition.

On another occasion, a network administrator had been asked by an associate dean of the school to develop a proposal for moving all personnel in his office to a common platform. After interviewing users and carefully collecting other data, the network administrator wrote a detailed financial and technical report recommending the purchase of IBM clones equipped with 486 processors and Microsoft Windows. He reasoned that this was cheaper than purchasing Macintoshes, that users would be able to continue to use their preferred software, and that the clones would put less stress on the network, which was not designed to handle Macintoshes easily. The dean ignored the technician’s report and mandated the purchase of Macintoshes, claiming that since the university’s central administration used Macintoshes, “we should too.” He countered the technician’s protest that this made no technical or financial sense by saying, “We’re [the administrators] going to do this. Now tell us what it costs. If we want to redecide, we will. Let’s be clear about who’s going to make the decision.” In fact, the dean’s decision did make little technical sense, since the people who worked in his office rarely shared data with the central administration, and when they did, platform incompatibilities could be handled by conversion software. The dean was an avid Macintosh enthusiast, and the technicians not so secretly suspected that his affect had clouded his reason. They also intimated that the dean was more willing to have his minions learn a new operating system than he was himself. Although technicians pointed to such incidents as blatant signs of disrespect, more than the technician’s dignity was at stake. As the last incident reveals, the ambivalence about whether technicians were to be servants or experts signaled a deeper ambiguity about the distribution of authority. It is for this reason that as an ideal type indicative of a larger
trend in the nature of work, technicians may well challenge
traditional forms of organizing.

IMPLICATIONS FOR ORGANIZING

Bureaucratic and most managerial theory presume that work
can be organized by a vertical division of labor in which
authority of position and expertise coincide. In a vertical
division of labor those higher in a hierarchy not only have
formal power over those below, they are assumed to have
greater expertise. In an ideal bureaucracy, superiors can
exercise authority legitimately only to the degree that their
knowledge encompasses, or is perceived to encompass,
that of their subordinates. The notion of an occupational
hierarchy headed by professionals whose knowledge
subsumes the paraprofessional’s rests on a similar
congruence of position and expertise, a congruence encoded
in the notion of a junior professional.

Historians and sociologists of work have shown that
authority of position and expertise were never as seamlessly
aligned as organizational or managerial theory has suggested
(Mechanic, 1962; Blau, 1964; Nelson, 1975). Nevertheless,
the jobs that were most characteristic of the industrial era
were relatively susceptible to strategies of industrial and
administrative engineering that sought to institute the ideal.
Moreover, existing cultural templates helped obfuscate what
industrial engineering failed to achieve. Unskilled and
semiskilled manual labor was especially susceptible to
rationalization, automation, and other techniques for
separating execution from cognition because it was generally
physical and repetitive (Taylor, 1911). Although the skilled
trades proved more difficult to tame, the fact that
tradespersons were manual, blue-collar workers facilitated
their assimilation under a vertical system of authority.
Clerical and mid-level managerial jobs were from the start
easily slotted into a vertical regime because their work was
created as owners and upper-level managers discarded their
more mundane tasks (Lockwood, 1958). The assimilation of
clerical work to a vertical division of labor was further
facilitated by the feminization of clerical jobs, which aligned
job status with traditional gender roles.

Technicians’ work caused trouble for vertical forms of
organizing precisely because it decoupled the authority of
position from the authority of expertise, a threat that was
particularly strong in the case of brokers. But even buffers
possessed substantial bodies of knowledge that their
superiors did not have. A significant component of this
knowledge was contextual and, hence, not easily formalized
or rationalized. Technicians’ work also required theoretical
sophistication which, in combination with manual and
perceptual skills, precluded easily assimilating technicians
beneath the cultural templates that we use to lend status to
work. Moreover, since technicians managed interfaces
critical to entire organizations, other people, including those
with more status and formal authority, had little choice but
to depend on technicians to work more or less
autonomously in a reliable, responsible manner. That
technicians did so despite the ambiguities and disdain they
sometimes encountered is strong testimony to an ethos of
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practice that technicians called a "professional" attitude (Nelsen and Barley, 1993a; Nelsen, 1996a).

The root of the problem was that technicians' work cleaved along occupational rather than administrative lines. For this reason, the growth of technicians' occupations signals a segregation of substantive expertise that, in turn, creates pressures for a more horizontal form of organizing. Occupational or horizontal divisions of labor evolve when knowledge and skills are domain-specific and too complex to be nested (Freidson, 1973). In a horizontal division of labor, individuals rather than positions become vessels of expertise. Knowledge is preserved and transmitted through extended training within a community of practice, rather than through rules and procedures. Coordination occurs not through a chain of command but through the collaboration of members of different groups working conjointly: a form of coordination in which practitioners retain authority over their own work.

Horizontal divisions of labor marked most Western economies prior to the nineteenth century. The social history of the industrial revolution is largely a story of how horizontal divisions of labor were dismantled and replaced by vertical divisions of labor (Nelson, 1975; Chandler, 1977; Jacoby, 1991). Today, horizontal divisions of labor are rarely dominant outside universities, R&D labs, the construction industry, and professional bureaucracies such as medical clinics and law firms. But to the degree that technicians' work is ideal typical of the trend we have dubbed the technization of work, pressures for an occupational logic of organizing may be rising.

The work relations that technicians described as most productive and satisfying generally had a horizontal structure. Technicians believed that professionals and managers had their own areas of expertise and that in those areas their judgments should be respected. They envisioned the ideal work environment as one in which people with different expertise worked as a team to solve problems, a cosmology of occupational specialization. In fact, many technicians played out their careers by moving from one organization to another until they found a situation in which they felt appreciated as experts (Barley and Bechky, 1994; Zabusky and Barley, 1996). Professionals also sometimes recognized the desirability of a more horizontal division of labor. For instance, comparing their relations with x-ray technicians (which were more vertical) to their relations with sonographers and CT technicians, radiologists in one hospital noted, "'X-ray has more of an industrial atmosphere.'"

It is worth noting that the growth of technicians' work is not the only development that points to the increasing importance of occupationally or horizontally structured work. To the degree that corporate downsizing focuses on mid-level management, it should amplify the demographic effects of technization by leaving behind a smaller labor force in which professional and technical workers represent a larger proportion of the employed (Prechel, 1994). Since World War II, organizations have hired increasing numbers of professionals (scientists, engineers, lawyers, physicians, etc.)
whose work is also occupationally structured. Furthermore, most of the decline in blue-collar employment has occurred among unskilled and semiskilled workers. The proportion of skilled tradespersons in the U.S. labor force today stands roughly at what it was at the turn of the century (Barley, 1996). Like professional and technical work, craftwork is occupationally structured. Finally, the splitting of general management into functional specialties such as marketing and finance, though long overlooked by students of work, suggests the possibility that even managerial activities may be becoming more consistent with a horizontal logic of organizing.

Viewed from this perspective, the rise of the technician as a modern ideal type combines with other developments to cast a somewhat different light on the growing consensus that traditional organizational structures are no longer adequate. Much of the new discourse on organizing revolves around a core set of images: the reduction of hierarchy, the empowerment of knowledgeable actors, and the use of teams, networks, and other means of lateral communication. Many of these images are consistent with movement to a more horizontal division of labor, yet rarely do commentators mention a more horizontal division of labor as an important reason for experimenting with organizational forms. Instead, the motivating forces are globalization, declining competitiveness, increasing environmental turbulence, and numerous variations on the themes of quality and efficiency. For instance, advocates of teams most often speak of enhancing commitment and involvement, rather than of linking specialists with complementary knowledge. Organizations claim they downsize because they are overstaffed and need to cut costs, not because new technologies and forms of work have made middle managers superfluous. Consultants portray empowerment as a motivational device or a means of enhancing quality, rather than a response to the fact that technical expertise increasingly lies in the lower echelons. Even scholars have neglected the importance of technization as a stimulus for organizational change. Organizational theorists, for example, often justify network structures in terms of transaction costs and strategic flexibility, rather than the much simpler postulate that hierarchies do not ensure knowledgeable action in a world of specialists.

To be sure, changes in the macroeconomic climate have surely spurred organizations to look for new options like collaborative organizing. Yet one cannot convincingly explain why organizations would toy with collaborative organizing unless one entertains the possibility of a shift in the nature of work and the decoupling of knowledge and authority. Although macroeconomic conditions may motivate firms to act, macroeconomic crises do not dictate, prima facie, that organizations should abandon traditional ways of structuring work. But if work is becoming more technical and occupational, then firms should find it increasingly difficult to improve productivity in a hostile economic climate by continuing to separate cognition from execution. Acknowledging a shift in the nature of work may enable us
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to reframe and more effectively address a number of
challenges.

An increasingly horizontal distribution of expertise not only
undermines hierarchy as a coordinating mechanism, it
undercuts management's source of legitimacy. When those
in authority no longer comprehend the work of their
subordinates, hierarchical position alone is an insufficient
justification for authority, especially in technical matters.
Under such conditions, leaders who insist otherwise risk
making decisions based on incomplete information, faulty
understandings, and criteria that sacrifice long-run
effectiveness, which, even in the absence of a turbulent
macroeconomic environment, should almost guarantee that
firms will perform poorly. The popular literature on
organizations intimates that failures of comprehension may
have indeed become common. Stories of organizations that
have acted without understanding their markets,
technologies, or production systems are a staple of the
business press. Morton Thiokol's and NASA's decision to
ignore the warnings of engineers regarding the behavior of
O-rings in cold weather is a particularly chilling reminder of
the cost of failing to appreciate what the separation of
position and expertise requires. Neuhauser (1988) has
written of the inability of managerial specialists to
communicate as a form of "tribal warfare," a theme echoed
by others in less sensational language (Dougherty, 1992).
Other commentators have indicted managers trained in
business schools for having short time horizons and for
failing to understand production systems (Dertouszos,
Lester, and Solow, 1989). Preliminary research by Scherer
and Huh (1992) indicates that technical firms headed by
chief executive officers with no technical training are less
profitable than those run by individuals with a technical
background.

But the consequences of failing to appreciate the
implications of technization extend beyond organizational
effectiveness. Relations of production are also at risk. Unless
managers are themselves technically trained, their claim to
be arbiters of technical issues is likely to seem capricious to
technical employees, a sign of hubris, if not stupidity. Such
perceptions were common among the technicians we
studied. Computer technicians complained that
administrators often made technical decisions for political or
personal reasons without appreciating the practical
implications of their actions. Medical, radiological, and
science technicians believed that physicians and scientists
who devalued their expertise did so primarily to preserve
their own status. The irony is that insisting on authority of
position in the absence of expertise drives a wedge
between management and a cadre of employees who are
generally committed to the organization's well-being and
recreates precisely the atmosphere of employment that
many new schemes of organizing intend to avoid.
Technicians whose superiors devalued their expertise quickly
learned to adapt by simply allowing their superiors to have
their way and suffer the consequences, a strategy well
understood among blue-collar workers.

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Adapting to a more balkanized distribution of expertise may ultimately require managers to view themselves occupationally as experts who specialize in the important but somewhat less heady task of coordinating resources and linking experts at the right time and the right place. Although discussions of changing managerial roles often make similar claims, evidence indicates that reengineering organizations rarely leads to a control structure consistent with a more horizontal division of labor. Hierarchical practices and ideologies have a way of reemerging even when managers are sincere about adopting more collaborative practices (Barker, 1993; Prechel, 1994).

Such observations reinforce what is perhaps the most critical inference to be drawn from a study of technicians’ work: The most serious barriers to adapting successfully to a changing world of work are likely to be cultural. Over the last two hundred years, Western societies have constructed a web of institutions and understandings premised on the dominance of a vertical division of labor. These range from notions of what constitutes a successful career to the way we should structure school-to-work transitions. If technicians are ideal typical of what a significant proportion of work will be like in a post-industrial economy, the difficulties of reengineering firms will pale before the cultural and institutional changes that we may need to contemplate. Potential difficulties include learning how to value and reward careers of achievement played out within the confines of an occupational community, rather than careers of advancement played out in organizations, and constructing a system that supports rather than dismantles occupational control over technical expertise and training. At present, the importance of such issues is only dimly recognized in the organization studies community.

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