"Technization" of the Workforce and the "Occupationalization" of Firms

Working Paper 92–08

Stephen R. Barley

CAHRS
Center
for
Advanced
Human
Resource
Studies

The New Crafts: On the "Technization" of the Workforce and the "Occupationalization" of Firms

Stephen R. Barley
School of Industrial and Labor Relations
Cornell University
Ithaca, New York
14851

First Draft
November 17, 1991

This research was sponsored by U. S. Department of Education through the Center for the Educational Quality of the Workforce at the University of Pennsylvania. The views expressed in this paper do not necessarily reflect those of either the Center or the U. S. Department of Education.

In the late 1960s and early 1970s American students were told that the value of a college education was declining (see Freeman 1976). Although liberal arts students were particularly discouraged by reports of recent graduates driving taxicabs, even the demand for engineers and other technical specialists seemed bleak. Two decades later, the headlines have reversed. Study after study proclaims that American children are performing more poorly on achievement tests than the children of most other industrialized nations. Employers complain of a shortage of skilled workers: young people are said to be ill-prepared for the demands of the workplace and older workers are said to lack the educational background requisite for retraining (Johnson and Packer 1987). Studies by labor economists have largely confirmed the employers' contentions and foretell of even greater shortages of skilled labor in the near future (Bishop and Carter 1991).

The new headlines have caused alarm, in part, because they affront our national pride. How could the United States, so long acknowledged as the educational Mecca of the world, have allowed its people to become so poorly educated? Even more troubling has been the fear that an inadequate educational system is somehow responsible for America's declining economic performance. Beneath such fear lies the perception that the rules of prosperity have changed. Whereas in the past our well-being flowed from the ability of a well paid, but largely unskilled, workforce to mass produce goods, future prosperity is said to hinge on the utilization of scientific and technical knowledge, the management of information, and the provision of services. In short, it appears that the future may depend more on brains than brawn.

Accordingly, national attention has turned to strategies for improving the education of the American people. Prominent initiatives include plans for reemphasizing math and science, schemes for attracting and retaining more talented teachers, funds for both on- and off-the-job training, and methods for improving the flow of information in the labor market. Although there is little doubt that the workforce of the future will indeed need to be better educated, it is unlikely that educational reform will by itself solve America's economic woes.

Reformers often speak as if tomorrow's firms will be much like today's with the exception that they will employ fewer and better educated workers and that they will pay more attention to training (Center for Advanced Human Resource Strategy 1991). If such a vision were accurate, the sudden crisis in workforce preparation could indeed be localized to the educational system. However, such an account ignores the most perplexing aspect of the educational crisis: the rapidity at which the tables seemed to have turned. What could have caused the educational system to become so poor so quickly and why should older Americans who were presumably schooled before the much heralded decline of standards also be found wanting? Could the escalating need for skilled labor be less of a symptom of our schools' failure than a harbinger of a more fundamental, but unanticipated, change in the division of labor? If the division of labor is shifting and if that shift demands a better educated workforce, then efforts to "upskill" the workforce may improve not only America's competitiveness, they may also accelerate a trajectory that could, in the long run, alter the very fabric of society.

At present the implications of a restructured division of labor for the social organization of work are not well understood. This paper highlights changes that seem to have contributed to the so-called crisis of preparedness, speculates on their potential implications for the workplace, and outlines a program of research on that segment of that labor force most clearly associated with the change: technical workers.

The Changing Division of Labor

The direction in which the division of labor is headed can be gleaned from Table 1, which displays, at ten year intervals since 1900, the percentage of the labor force employed in the Census Bureau's eight broad occupational categories. The table clearly indicates that the occupational structure of the U. S. has changed dramatically since the turn of the century. Most obvious and well-known has been the demise of agricultural employment, a trend that actually began during the 19th Century (Porat 1976; Bell 1979). In 1900 agriculture was still the most significant source of employment: 38% of all Americans worked on farms. By 1988, a mere 3% of the population were so employed. The shift away from an agriculturally dominated workforce was largely complete by 1960 when, for the first time, no other occupational category employed fewer people.

If the first half of the 20th Century consummated America's decline as an agrarian society, the second half signaled its demise as a manufacturing society. Direct employment in the production of goods peaked during the 1940s when 4 out of 10 Americans worked either as craftspersons or as operatives and laborers. By 1988, the percentage had fallen to 36 percent. Because the crafts retained a relatively stable proportion of the labor force throughout the century, manufacturing's decline occurred primarily at the expense of semiskilled and unskilled labor. Between 1940 and 1988, the percentage of the labor force employed as operatives and laborers fell by 12%. It would therefore seem that blue-collar work, as it is typically conceived, dominated the division of labor for a span of 50 brief years: operatives and laborers had become the most prevalent occupational category by 1930, but had ceased to be so by the mid-1980s.

As is widely known, the demise of agricultural and blue-collar work was offset by tremendous growth in the "white-collar" labor force. The percentage of Americans employed in managerial, sales, clerical, professional, and technical occupations rose from a mere 18% of the working population in 1900 to 56% in 1988, an increase of 36 percentage points. Although the rise of white-collar work is hardly news, several of the dynamics by which the shift occurred are less well appreciated.

Analysts often suggest that an expansion of clerical and service jobs largely compensated for declining agricultural and manufacturing employment. Consequently, one frequently hears that the American economy is being transformed into a service economy marked by low paying jobs in fast food franchises and clerical sweatshops (Bluestone and Harrison 1982; Levin and Rumberger 1983; Rumberger 1986). The data in Table 1 pose difficulties for such claims. Clerical occupations have indeed grown tremendously since the turn of the century. Clericals now account for 13% more of the working population than they did in 1900. However, most of this growth occurred during the first half of the century when three quarters of the 13% increase occurred. In fact, clerical employment has declined in prominence since 1970 when it peaked at 18% of the labor force.[1] Thus, if clerical occupations helped to absorb the decline in agricultural and manufacturing jobs, they did so primarily before the 1950s.

Even more problematic for the claim that America is becoming a service economy are data on employment in the service occupations. Although the service sector expanded during the 20th Century, with the exception of craftworkers, service occupations grew less extensively than any other occupational classification. From 1900 to 1988 employment in service work increased by only 4%. Thus, it appears that since 1950 much of the growth in the white-collar labor force has occurred among managerial, sales, and especially professional and technical occupations.

Professional and technical occupations have accounted for the largest proportion of the non-clerical shift to a white-collar workforce. Since 1900 professional and technical work's share of employment has increased by 12%, a rate of growth exceeded only by the clerical occupations. However, in sharp contrast to the clerical workforce, three quarters of the increase in the professional and technical workforce occurred after 1950. In fact, since World War II, professional and technical work has grown more rapidly than any other occupational sector. As Figure 1 indicates, the number of professional and technical workers increased by 282% over the last four decades. Only sales occupations grew at even a remotely similar rate. By 1988 professional and technical workers were tied with clericals and with operatives and laborers for the status of most prominent occupational category: each group accounted for 16% of the working population.

Economic forecasts indicate that professional and technical occupations will continue to grow rapidly. Table 2 provides one such estimate based on the Silvestri and Lucasiewicz's (1989) projected growth rates for each occupational sector assuming that the economy as a whole grows moderately. Not only are professional and technical occupations projected to be the fastest growing

---

[1] The 2% decline over the last two decades probably reflects, at least in part, the computerization of office work.

segment of the labor force, but by the turn of the century professional and technical workers should account for more employment (18%) than any other segment. Over a quarter of all new jobs created between 1990 and 2000 are anticipated to be professional or technical jobs. If, as some labor economists argue, the government's estimates are conservative, then professional and technical occupations may represent as much as 20% of the workforce by the year 2000 (Bishop and Carter 1991).

Hence, the story told by data on the occupational division of labor in the United States is not simply one of movement from a blue-collar to a white-collar society. The data strongly indicate that America has become embroiled in what might be labeled the "technization" of the workforce. Over the course of the decade, professional and technical workers have been catapulted from the second most peripheral occupational category to what may be the core of the labor force by the next century. Several interwoven dynamics have spurred the transformation.

Engines of Change

The Bureaucratization of Professions

Perhaps the most subtle dynamic has been the trend toward ever larger and more bureaucratic organizations (Zucker 1983) With the exception of engineers, at the turn of the century, most professionals worked either as solo practitioners or in small partnerships. Doctors, lawyers, and accountants served clients from their homes or offices and played an economic role in their communities similar to that of small businessmen. Over the 20th Century solo practice dwindled. Between 1931 and 1980 self-employment among physicians fell from 80% to approximately 50% (Derber and Schwartz 1991). Similarly, less than one-third of all lawyers in the U. S. now work as private practitioners, whereas in 1950 over 50% were so employed (Spangler 1986). Even in relatively rural areas professional services are today frequently dispensed by law firms, accounting firms, hospitals and other professional bureaucracies that hire professionals as salaried employees.

Professional bureaucracies have spawned employment opportunities for professionals in two ways. Because hospitals, law firms, and accounting firms have access to more resources than do solo practitioners, they can afford equipment and facilities that enable them to provide services that clients could not otherwise obtain. The provision of such services increases the population's demand for the profession's expertise, thereby enabling professional bureaucracies to support more practitioners per capita than would occur under a regime of solo practice. Professional bureaucracies have also created an organizational context conducive to specialization. Because professional bureaucracies collocate practitioners, they can employ specialists and still provide breadth of expertise. On average, specialization requires that more practitioners become involved in meeting the needs of a client.

Bureaucratization and the trend to larger organizations affected the demand for professionals in several other ways. Large organizations consume professional services, especially those offered by lawyers and accountants. As the number of organizations increased, corporate demand augmented individual demand for professional services thereby enlarging the market for professional employment. In some occupations, such as law and accounting, corporate demand eventually surpassed individual demand. Moreover, as corporations grew they discovered that it was often cheaper, if not more effective, to provide for themselves expertise that they formerly purchased from solo practitioners or professional bureaucracies. Accordingly, corporations began to hire their own professionals which further increased demand. Recent examples of the importation of professionals into corporate settings include the growth of legal departments in multinational firms and the creation of corporate medical units charged exclusively with caring for a firm's employees.

Expansion and Application of Scientific Knowledge

A second important reason for the growth of the professional and technical workforce has been the increasing centrality of science to modern society. Price's (1986) research on the growth of science indicates that scientific knowledge has expanded exponentially since the 17th century.

Price estimated that by the 1960s scientific output was doubling every 6 to 10 years, a rate of growth "much faster than that of all the nonscientific and nontechnical features of our civilization" (Price 1986: 141). As Price was fond of noting, 90% of all scientists who have ever lived are alive today.

Science's explosive growth has been sustained, in part, by the realization that scientific and technical knowledge could generate considerable profits. The commercialization of chemistry and physics during the last two decades of the 19th and the first half of the 20th Centuries gave rise to the industries on which the modern economy pivots: aerospace, automobiles, energy, pharmaceuticals, petrochemicals, and electronics. Advances in the life sciences, especially in immunology, microbiology, biophysics, and biochemistry, largely underwrote the expansion of the health care industry that began after World War II. More recently, molecular biology and its associated technologies have opened opportunities for entirely new industries and have revolutionized others (Barley, Freeman, and Hybels 1992; Teitelman, 1989; Olsen, 1986).

The explosion of scientific knowledge, both basic and applied, brought a burgeoning demand for scientists, engineers, technicians and health professionals. However, the expansion and commercialization of science did not simply enlarge existing fields, but it also triggered a proliferation of new occupations. Two processes have figured prominently in science's contribution to the growth of the technical labor force: specialization and the "hiving off" of work.[2]

As the stock of knowledge in a discipline becomes more complex, scientists and other professionals find it increasingly difficult to remain generalists. Breadth of knowledge is attained at the expense of depth, and visa versa. While generalists may be quite effective at screening problems and clients, they are less prepared than specialists to advance a field's knowledge or provide state-of-the-art services. Since the latter activities are more highly valued, most sciences and professions have adopted a strategy of specialization, the carving of cognate areas into ever

[2] The term, "hiving off," is adopted from Smith (1987). The concept, though not the term, probably entered the sociological literature with Hughes (1958).

narrower subfields. Specialization increases the number of employed professionals not only by opening up new territory, but by requiring collaboration. Under a regime of specialization, increasingly few individuals can execute alone tasks that require both breadth and depth of expertise.

Overburdened professionals have also sought to curb their workloads by allocating routine duties to somewhat less well-trained individuals. Many of the technical and "semi-professional" occupations that have flourished in the later half of the 20th Century originated in the "hiving off" of "dirty" work by the established professions. The phenomenon has been most visible in health care where licensed practical nurses, medical technologists, radiological technologists and an ever expanding array of technicians have coalesced into occupations around tasks discarded by their more prestigious brethren (Hughes 1958). However, the dynamic is also prevalent outside health care where it has given birth to a plethora of technical occupations ranging from the reasonably well-known (paralegals, electronics technicians, chemistry technicians) to the amazingly obscure (test and pay technicians, see Kurtz and Walker 1975).

Technological change

Perhaps the most important force for the growth of the professional and technical workforce has been technological change. Throughout history technologies have spawned new occupations. The wheelwright, the blacksmith, the machinist, the automobile mechanic, and the airline pilot are but convenient illustrations. In the past, technologies created occupations across the entire division of labor. Modern technologies have also sired occupations in all strata, but those with a high technical content appear to have become more common.

Commentators usually credit this change to the advent of the computer. In 1950 few people worked with computers and most who did were mathematicians (Pettigrew 1973). By the 1970s computers had given birth to such well-known occupations as programmer, systems analyst, operations researcher, computer operator, and computer repair technician. These occupations, which now employ over 1.36 million workers, continue to be among the fastest growing. By the turn of the century they are anticipated to provide employment for 1.99 million people.[3]

However, the explosion of occupations directly related to the computer is only the most visible sign that technology may now favor the technical and professional workforce. Numerous technical occupations have been created of the last four decades by technologies other the computer: for instance air traffic controllers, nuclear technicians, nuclear medical technicians, broadcast engineers, technical writers, and materials scientists. Moreover, computers have altered the contours of many more traditional jobs. In the long run, the effects of computerization on existing lines of work may prove to be the most important force for the technization of the workforce.

To grasp how computers have accelerated the technization of work by altering existing jobs, one must distinguish between two broad types of technological change. Most technical change is *substitutional*: the replacement of an earlier technology by a more efficient or effective successor. Examples of technical substitutions are legion: pens for pencils, jackhammers for picks, jet planes for prop planes, and so on. Historically, technological substitutes have made work easier to perform and have generated considerable profits by reducing labor costs and allowing economies of scale. However, the effects of substitutional change tend to be localized to specific industries simply because the tasks that the technologies perform are, by and large, peripheral to the economy as a whole.

Infrastructural technological change is quite different and more rare. Infrastructural technologies are the relatively small set of technologies that form the cornerstone of a society's system of production during an historical era. Until recently, the economies of the advanced industrial nations have revolved around electrical power, the electric motor, the internal combustion engine and the telephone (Coombs 1984). Anthropologists and sociologists have repeatedly shown that technical infrastructures shape not only a society's economy but also its cultural institutions

---

[3] Estimates are based on data from Silvestri and Lukasiewicz's (1989) estimates for a moderate growth scenario.

(Marx 1970/1859; Spicer 1952; Pelto 1973; Bell 1973; Harris 1979; Pacey 1983). Accordingly, when societies experience a change in their infrastructure one can expect rather far reaching reverberations.

American society last encountered a shift in its technical infrastructure during the late 19th and early 20th Century (Hughes 1983; Hounsell 1984). The shift, sometimes termed the Second Industrial Revolution, was largely responsible for America's move from an agrarian to a manufacturing economy and was accompanied by a tremendous upheaval in American culture. Urbanization, the growth of corporations, the rise of professional management, the demise of religion and the disintegration of the extended family are among the more prominent trends that can be traced to the restructuring of the economy by electrical power, the telephone, and the internal combustion engine.

The danger of infrastructural change is that people tend to treat it as if it were substitutional change, thereby underestimating the technology's impact. For instance, Pelto's (1973) study of the transformation of Skolt Lap society in the decade following the Skolt's first encounter with the snowmobile makes clear that Skolt reindeer herders wrongly viewed the snowmobile as little more than a faster and more efficient means of herding. Similarly, Americans at the turn of the century embraced the automobile as a "horseless carriage" little anticipating that the car would transform their way of life in less than 50 years (Fink 1975).

Recent developments strongly suggest that the industrialized West is again experiencing an infrastructural shift based on the development and diffusion of computational controls (Beniger 1986). The computer, as it is normally conceived, is only the most visible part of the change. Our growing knowledge of how to convert electronic and mechanical impulses into digitally encoded information (and visa versa), and how to transmit such information across vast distances is gradually enabling industry to replace its electro-mechanical infrastructure with a computational infrastructure. The ramifications of a computational infrastructure for the workforce are potentially staggering. For instance, it is already possible to run an entire factory from a bank of terminals located in an air conditioned control room (Zuboff 1989). Similarly, engineers can now design parts on a CAD system in one city and have them machined in another without human intermediaries (Ruszic 1981).

Yet, most firms continue to justify even the most sophisticated computational technology with the logic of substitution. From this perspective, personal computers appear to be little more than more efficient typewriters, computer controlled machine tools are a quicker and more reliable means of machining, and electronic messaging is simply a faster way to deliver the mail. One can frame computational technologies as a technological substitutes only be ignoring their cybernetic nature. Like traditional servo-mechanisms, cybernetic technologies execute tasks via "effector links," but unlike servo-mechanisms they also acquire information on the state of the task via "feedback" links (see Figure 2). Because the concept of an effector has long supported the economic logic of automation and because the cost/benefit analyses associated with automation are well understood, firms often emphasize only the effector link when justifying a purchase. However, as Zuboff (1985) cogently notes, computational technologies do not simply automate, they also "informate". That is, they allow their operators access to previously unavailable information and require skills that have not normally been expected of a machine's user. Ironically, in the case of computational control both the automating and the informating capacities of the technology have exacerbated the technization of work.

Although, in theory, automation can reduce costs simply by increasing productivity, firms often hope that automation will enable a reduction of the workforce and a shift to less skilled labor. However, deskilling does not usually occur simply because a technology can now perform a task previously performed by a human. Technologies typically automate the most routine parts of a job simply because routines are easier for designers to program. To successfully deskill workers, firms must usually reallocate the more complex aspects of a target occupation's work to another occupation. Since the occupations that benefit from such reallocations tend to acquire cognitive and technical responsibilities, deskilling unintentionally expands the number of technical workers. For instance, Smith (1987) has argued that the reallocation of cognitive skills previously exercised by craftsmen and foremen was largely responsible for the birth of such technical occupations as rate-fixers, estimators, and inspection and planning engineers. Similar arguments have been made for the rise of NC programmers and schedulers in machine shops (Braverman 1973).

Even when skills are not reallocated, automation may still skew a firm's labor force toward technical employees if the employment of unskilled and semiskilled labor declines. DiPrete (1988) and Attewell (1987) have shown that two decades of computerization have altered the workforce of firms in the insurance and banking industries by precisely such a path. Although office automation enabled firms in these industries to reduce their reliance on lower level clerks, the relative importance of more highly skilled workers (particularly those who program and maintain computers and databases) has increased as the number of clerical employees fell.

The capacity of computational technologies to informate work has been even less well anticipated. Accumulating evidence indicates that computational systems may bring a technical component to nontechnical and even semiskilled work. For instance, Zuboff (1989) concluded from her studies of computer integrated paper mills that the technology required blue-collar operators to analyze data and then make decisions based on their analysis in order to control the production process effectively. In the past, such skills were reserved for mid-level managers. Similar findings are common among studies of machinists and operatives in manufacturing plants that have adopted computerized numerical control and other forms computer automated manufacturing (Majchrzak, 1988). Nor are such dynamics confined to the factory floor. Barley's (1990) research on medical imaging indicates that radiological technologists must learn to interpret pathological signs in order to operate CT scanners, ultrasound, or digital subtraction angiography. The need for such skills threatens radiology's longstanding mandate that technologists be barred from interpretive knowledge. Finally, Nelsen's (1991) pilot study of secretaries in universities suggests that the spread of personal computers among faculty members is slowly shifting the secretary's work toward that of a research assistant.

The message of such studies is consistent. As the technical infrastructure becomes increasingly computational, even blue-collar workers will be asked to process abstract, symbolic information and to engage in procedural and mathematical reasoning in order to accomplish their work. Computer integrated technologies demand that workers understand the larger production system of which they are a part and make decisions formerly reserved for occupations with higher status.

In sum, the technization of the labor force appears to be driven by four general dynamics: (1) an increased demand for members of existing professional and technical occupations, (2) the proliferation of new occupations with a technical and scientific core, (3) declining employment among the ranks of the semiskilled and unskilled, and (4) the infusion of analytical and technical content into jobs that have not traditionally been considered technical in nature. The movement toward an increasingly technical workforce not only creates a need for a better educated workforce, it also poses a significant challenge for way in which the workforce and the workplace are currently conceptualized and organized.

The Occupationalization of Organizations

Vertical and Horizontal Divisions of Labor

Broadly speaking, two models exist for dividing labor in a society or organization. In a *vertical division of labor* authority and expertise are arranged hierarchically. Those higher in the hierarchy not only have power over those below, but they are generally assumed to have greater expertise. In fact, in a vertical division of labor superiors can exercise authority legitimately only to the degree that their knowledge encompasses, or is perceived to encompass, that of their subordinates (Weber 1968/1922). Vertical divisions of labor presume that knowledge and skills can be nested in cumulative fashion. Because vertical divisions of labor encode expertise in rules, procedures and positions, organizations are usually have been the primary tool for preserving and enacting expertise (Abbott 1991). In most instances, the knowledge associated with a position of the hierarchy is relatively specific to the organization in which the hierarchy exists.

In sharp contrast, authority and expertise are balkanized and allocated to members of distinct groups in a *horizontal division of labor.* The logic of a horizontal division of labor rests on the assumption that knowledge and skills are domain specific and too complex to be nested. Consequently, individuals rather than positions become the vessels of expertise in a horizontal division of labor. Knowledge is preserved and transmitted through extended training 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. Members of each group retain authority over their own work while interacting with members of other groups to manage the interface of their respective components of a task. In a horizontal division of labor, skills and knowledge tend to be transportable across work sites.

Although scholars agree that a horizontal division of labor characterized Western society until the late 1700s, since the beginning of the 19th Century a vertical division of labor has become increasingly dominant. In fact, sociologists have long argued that vertical models for organizing labor lay at the core of the cultural transformation known as the Industrial Revolution (Durkheim 1933/1893; Tonnies 1957/1887; Weber 1968/1922). The vertical dimension now so overshadows our thinking that it suffuses most of the cultural categories by which we make sense of work. Terms such as "manager", "capitalist", "white-collar" and "mental work" usually invoke images of the upper echelons of a vertical division of labor. "Worker", "proletariat", "blue-collar" and "manual work" imply stations in the lower echelons. Even occupational terminology has been pressed into a vertical mold: professions are said to be "above" the "semi-professions" which, in turn, are said to be "above" the crafts.

The Anomalous Position of Technical Workers

However, the professional and technical workforce has never neatly fit a vertical scheme for classifying labor. The fit has been particularly troublesome for technical workers. Technicians often wear white collars, carry briefcases, conduct relatively sophisticated scientific and mathematical analyses, and speak with an educated flair. Yet, technical workers use tools and instruments, work with their hands, make objects, repair equipment, and perhaps most importantly, get dirty. Like those in higher echelons, technical workers have considerable autonomy and are often trusted by their employers. 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 (Franke and Sobel 1970), accorded low status, and may be subject to stringent bureaucratic controls (Orr 1991).

Most commentators have sought to resolve such anomalies either by claiming that professional and technical workers exist outside the vertical division of labor or by forcing them into positions within a vertical frame. The first strategy long dominated research on the professions. Early sociological analyses of the professions almost invariably assumed that solo practice was not only the prototypical but the proper form of professional employment (Goode 1957; Parsons 1968). In fact, much of this work concentrated on explaining status differences among occupations and ignored the context of professional work altogether (Parsons, 1939; Davis and Moore, 1949; Merton, 1960). With few exceptions (Marcson 1960; Smigel 1964; Strauss, et al, 1964), even ethnographers of professional practice wrote as if professionals were unfettered by the constraints of an organizational division of labor.

It was not until the 1960s that sociologists began to examine the employment of professionals by organizations. But because researchers continued to measure professional work by the yardstick of independent practice, the bureaucratic employment of professionals was often treated as an aberration. Sociologists of the period spent much ink explaining why organizationally-embedded occupations, such as engineering and nursing were not "real" professions (Becker and Carper 1956; Kornhauser 1962; Perrucci and Gerstl 1969; Ritti 1968; Etzioni 1969). In the sociological paradigms of the time, the attributes of bureaucratic and professional work were simply antithetical (Freidson 1971). Theoreticians predicted that this conflict would lead to alienation among bureaucratically employed professionals. Although researchers repeatedly uncovered little of the anticipated discontent (Scott 1965; Miller 1968; Hall 1968; Ritti 1971), recent work on professionals and organizations has resurrected themes common in the 1960s (Raelin 1985; von Glinow 1988).

Conflict between professions and organizations attracted renewed attention in the late 1970s when Marxist scholars began to suggest that many, if not all, professions were well on the road to "deprofessionalization" (Haug 1973; Toren 1975; Kraft 1978; Greenbaum 1979). Paralleling Braverman's (1974) description of the deskilling of craft work, deprofessionalization theorists argued that organizational employment enabled capitalists to increase their power over professionals by effectively stripping them of their ability to control their work. Deprofessionalization theory predicted that the professions' power and autonomy would decline as they became more organizationally bound. Either professionals would be transformed into managers or staff or reduced to another form of wage labor.

The forcing of technical and professional work into a vertical framework has been even more prevalent in the literature on technicians. Marxist scholars of the technical workforce have concentrated on determining to which class technical workers rightfully belong. One camp conceives of technical workers as a "new middle class" whose interests are implicitly aligned with those of management and capital (Poulantzas 1978). Others claim that technical workers are a "new working class" because they engage in productive and manual labor (Mallet 1975; Gorz 1976). More empirically oriented Marxists have generally concluded that technicians are a bit of both and, hence, should be considered "intermediate workers," a term which also lacks meaning except when cast against a vertical background (Smith 1987; Wright 1979).

Weberian sociologists, labor economists and managerialists have also grappled with technical work's marginality (Roberts, Loveridge, and Gennard 1972; Drucker 1979; Hendry 1990; Orr 1991). However, instead of using the class structure as their yardstick, such analysts employ either an organizational hierarchy or a vertical rendition of the occupational structure as a backdrop. Most have concluded that technical workers are difficult to classify and control because their work possesses attributes of both administration and craft (Zussman 1985, Whalley 1986). Accordingly, technical workers are usually assigned to an intermediate position in the organizational or occupational hierarchy.

The difficulty with such conclusions is not that they are unreasonable, but that they deal with only part of the picture. Vertical and horizontal divisions of labor have never been mutually exclusive: in many firms both forms of organizing have long existed side by side. However, outside professional bureaucracies, work has been dominated by employees whose skills easily fit a hierarchial order. Consequently, the horizontal division of labor in such firms was relegated to secondary status. With the technization of the labor force, scholars and managers can no longer simply assume that the vertical will continue to overshadow the horizontal.

Figure 3 cross-classifies occupational groups by concepts pivotal to vertical or horizontal divisions of labor. The vertical dimension is captured by whether an occupational group has a authority to command and control. The horizontal dimension is signified by the degree to which the group's skills and knowledge generalize across work sites. Managers and professionals inhabit the upper echelons of a vertical division of labor because both usually have the authority to command. However, a manager's substantive knowledge is usually more contextually bound than a professional's. Clericals, operatives and craftspersons inhabit the lower rungs of the vertical division of labor because they have little or no authority to command. However, like professionals, the substantive knowledge of a craftsperson is more context-free than that of a clerk or operative. Consequently, occupational groups on the left side of the table are defined primarily by the vertical division of labor while those on the right also strongly participate in a horizontal division of labor.

As organizationally embedded professions expand and proliferate, the balance of a firm's labor force clearly shifts toward the upper right of Figure 3 thereby magnifying the importance of the horizontal division of labor. The implications of a broader technization of the workforce are less clear. As the overlay labelled "technicians" in Figure 3 suggests, some new occupations that carry the technician's moniker resemble traditional clerical occupations. For instance, the work of "scanning technicians" who create digital facsimiles of printed materials (Baynes, 1991) is akin to the work of a copy machine operator. Other technical occupations, such as electrical engineering and systems analysis, for all practical purposes have obtained the stature of professions. These occupations have formal training programs, professional associations, professional journals and various forms of credentialling. However, the occupations that epitomize the technization of the workforce (e.g. science technicians, engineering technicians, radiological technologists, emergency medical technicians, technical writer, computer programmers, etc) have a more ambiguous status. While they clearly enlarge the horizontal division of labor, they blur the attributes of craft and profession.

New Crafts

Table 3 illustrates this blurring by situating technicians' work with respect to attributes that sociologists usually ascribe to crafts and professions. Technicians resemble professionals in that their work is sufficiently esoteric that few outsiders can claim to possess the skills or knowledge that anchor the occupation. Moreover, their work is relatively analytic and often requires specialized education. Many, but not all, of the major technical occupations have even developed occupational societies and journals. However, in other ways, technical occupations more closely resemble crafts. Apprenticeships and on-the-job training play a crucial role in the education of technicians just as they do in the training of craftspersons. In fact, a significant minority of engineers and technicians are trained solely by apprenticeship (Zussman 1985; Whalley 1986; Smith 1987). Moreover, like craftspersons, many technicians operate equipment, create material artifacts, and possess valued manual skills. Outside health care, certification and other forms of control over entry are rare. Finally, like craftspersons, technicians are more likely to unionize than are professionals. The tendency for technicians to unionize is especially strong in Europe.

Although few in number, ethnographies of technical occupations support the notion that technical work resembles a craft. Craftspersons have long been valued for their "artisanal" knowledge: the ability to render a skilled performance based on an intuitive feel for materials and techniques (Harper 1987). Artisanal skills are acquired primarily through practice and are difficult to verbalize, much less codify. They reside in the practitioner's ability to read subtle visual, aural, and tactile cues where novices would see no information at all. Accordingly, craft knowledge is spread informally through a community of practice by guided learning-by-doing and by exemplars embedded in stories about previously accomplished work (Orr 1990).

Studies of engineers consistently report that engineers consider their formal analytic training to be far less relevant than the practical knowledge of materials and machines acquired while on the job (Bailyn 1980; Zussman 1985). Artisanal knowledge may be even more prominent among technicians (Barley 1988a 1988b; Orr 1990; Jordan and Lynch 1989). Cambrosio and Keating (1988) and Bechky (1991) concluded that although technicians in monoclonal antibody labs possess considerable scientific training, they are often unable to fully articulate their techniques for producing viable hybridomas. Consequently, biotechnologists frequently can not duplicate each other's work even when procedures have been meticulously documented in scientific papers and protocols. Thus, the transfer of technical knowledge often requires that a lab dispatch its technicians and, even then, the recipient may be unable to cultivate the cell line successfully.

Orr (1991) discovered that technicians who repair Xerox machines also largely depend on an oral culture of artisanship. Orr reports that service technicians frequently find the company's technical documentation to be inadequate for diagnosing and repairing broken copiers. Although perplexed technicians used the documentation as a resource, they relied more heavily on stories of past encounters with broken machines. The stories served as exemplars rich with contextual details and other diagnostic cues. The documentation was not deemed inadequate because the machine's designers had omitted necessary information. Instead, the crucial information was unknown to the designers because it could not be discovered until the copier was in use and in need of repair.

Thus, existing evidence suggests that the technization of work may not only enhance the importance of a horizontal division of labor, it seems to engender a new breed of occupations.

Members of such occupations may require considerable formal knowledge of science, math, and technology, yet their most valued skills appear to be those developed in a hands on conversation with materials and techniques. Scientists, engineers and other professionals almost always possess greater formal knowledge than the technicians who work under their supervision. However, professionals rarely possess the artisanal skills that enable technicians to conduct a flawless experiment, perform an adequate test, or operate a complex instrument without mishap. It is this artisanal knowledge which makes technical workers indispensable to their employers and at the same time provides them with power and autonomy (Barley 1990). Technicians' artisanal skills may serve as grounds for the formation of fledgling occupational communities within, if not across, firms (Van Maanen and Barley 1984).

The majority of technical occupations might therefore be usefully conceptualized as "new crafts". Although such occupations usually lack the guild-like structure of a traditional craft, their relation to management and other occupational groups seems quite similar. Like machinists, carpenters and electricians, technicians command the mysteries of techniques and materials that lie at the core of an enterprise's system of production. Whereas the older crafts were masters of wood and metal, the materials of industrial society, the new crafts control the mysteries of scientific procedures, software, and data -- the materials of post-industrial society. As such occupations proliferate alongside an expanding professional workforce, firms are likely to become increasingly occupationalized (Barley and Tolbert, 1991). Traditional organizational practices based solely on a vertical conception of the division of labor may therefore become increasingly suspect, if not ineffective.

The Mandate for Studying Technical Work

The expansion of the technical and professional workforce implies that coordination based solely on the authority of position will grow more tenuous for several reasons. First, unless managers are themselves technically trained, the claim that their expertise encompasses that of their subordinates will ring hollow to members of the technical labor force thereby undercutting management's legitimacy. Second, to the degree that technical issues are central to a firm's operation and strategy, managers may find that they need to involve technical workers in decision making precisely because they lack the necessary expertise. Third, to the extent that core tasks require the expertise of various technical specialists, team structures and collaborative systems are likely to become more crucial for daily operation. Finally, to the degree that technical workers possess esoteric but critical knowledge and skills, firms may need to adopt a new vision of the employment relationship if they are to retain not only their employees but information crucial to the firm's continued operation. In short, by embedding expertise in individuals rather than positions, rules and procedures, occupationalization will require firms to mesh vertical and horizontal work cultures that have for so long been treated as incommensurate.

At present we know very little about either the technical workforce or how it is articulated within vertically structured organizations. Even studies of the work of engineers have been rare. Although research on the attitudes of engineers' flourished during the late 1960s (Peltz and Andrews 1966; Perrucci and Gertzl 1969; Ritti 1971), social scientists have only recently undertaken contextualized studies of engineering practice (Zussman 1985; Whalley 1986). Far less is known about technicians and other technical workers. Although there have been a few studies of emergency medical technicians, radiological technologists, and other health care workers (see Metz 1981; Barley 1990), studies of technical work outside heath care settings comprise an nearly empty set. Therefore, to understand the organizational implications of the technization of the workforce, will gathering significant amounts of data on technicians and their relations with employers and members of other occupational groups.

Accordingly, researchers associated with the Program on Technology and Work at Cornell's School of Industrial and Labor Relations have undertaken, with financial support from the Center for the Education of the Workforce, a five year program of research on the technical labor force. The research pivots on collecting detailed ethnographic data on a variety of technical occupations spanning various work settings and organizations. Through coordinated fieldwork, the researchers aim to build systematically a comparative database to facilitate the development of a grounded theory of technical work.

As Figure 4 indicates, the research program is structured as a matrix formed by studies of specific occupations linked by cross-site comparative analyses. The design dictates that each ethnographer undertake prolonged field study of one or more technical occupations. Occupations have been selected to represent the different paths by which technical work arises as well as the various contexts in which technical workers are employed. Because the ethnographies seek to depict technical practice from the perspective of an insider, each requires from 6 to 12 months of fieldwork. Although the studies are intentionally tailored to the contours of the occupations under investigation, each ethnographer also pursues a number of common foci to facilitate comparative analyses. Common foci include: (1) the occupation's formal and informal structure, (2) the way in which technical workers understand themselves and their work, (3) the skills, abilities, and attitudes of the occupation's members, (4) the way in which members are trained and socialized, (5) career paths available to those in the occupation, and (6) relations between members of the occupation and members of other occupational groups including management. As the vertical arrows of the matrix indicate, each study is intended to yield papers and monographs that depict key features of the occupation's culture, structure, and practice.

In addition to pursuing separate studies, researchers participate in weekly team meetings. The team meetings provide a forum for surfacing and then analyzing commonalities and differences among the occupations under investigation. Comparative analyses facilitate the synthesis of data from the various studies into a more general, but grounded, theory of technical work. The integrative analyses are structured to yield co-authored papers and monographs on issues that cut across occupations and organizational settings. As the horizontal axis in Figure 4 indicates initial topics for integrative analysis include: (1) development of a definition of technical work and the technical labor force, (2) the role of training and skill in technical occupations, (3) the management of uncertainty in technical operations, (4) the social construction of "professional" identities, and (5) the role of instruments, equipment, machines, and scientific knowledge in the daily round of technical work.

The research program has been designed to unfold in a series of phases linked to the different organizational contexts in which technical workers are employed and different levels of generality. Each phase will encompass a wave of studies. During the first 18 months of the project (November 1990 to May 1992), researchers will focus on technical workers in university and health care settings. The initial wave of ethnographies, currently underway, includes studies of science technicians in university laboratories, emergency medical technicians, medical technologists in pathology labs at community hospitals, and technicians in a university library. Several of the occupations are rooted in the "hiving off" of professional routines (medical technologists, science technicians in general), others have been created by the advent of new technologies (technicians in libraries, monoclonal antibody technicians) and yet another has evolved from amateur work (EMT's).

The second wave of ethnographies, scheduled to begin in the Spring of 1992, will focus on technical workers in industrial and other for-profit contexts. Occupations to be examined may include: microcomputer specialists, engineers and engineering technicians in R&D labs, air traffic controllers, broadcast technicians, programmers, and machinists. During the second phase, ethnographies of factories which have adopted computer integrated manufacturing systems will also be launched in an attempt to delineate advanced technologies may be altering the skills and social organization of work not traditionally construed as technical. During the last phase of the project (beginning in the Fall of 1993), randomly selected members of technical occupations in a variety of work contexts will be surveyed. The survey research will be designed to illuminate theoretical issues that have surfaced over the course of the study as well as to collect general data on the attitudes, skills, training, and careers of technical workers.

References

Abbott, Andrew. (1991) The future of professions: Occupation and expertise in the age of organization. Pp. 17-42 in Pamela Tolbert and Stephen R. Barley (eds.) *Research in the Sociology of Organizations*. Greenwich, CT: JAI Press.

Attewell, Paul. (1987) The Deskilling Controversy. *Work and Occupations*. 14:323-346.

Baynes, Timothy (1991) Unpublished field memos on scanning technicians' work. School of Industrial and Labor Relations, Cornell University.

Bechky, Beth. (1991) *In the Back Room of Science: Tacit Knowledge and the Social Construction of Technical Work in Laboratories.* Senior Honors Thesis. School of Industrial and Labor Relations. Cornell University.

Bell, Daniel (1973) *The Coming of Post-Industrial Society.* New York: Basic Books.

Bell, Daniel (1979) The social framework of the information society. Pp. 164-211 in Michael L. Dertouzos and Joel Moses (eds), *The Computer Age: A Twenty Year View.* Cambridge, MA: MIT Press.

Bailyn, Lotte. (1980) *Living with Technology: Issues at Mid-Career.* Cambridge, MA: MIT Press.

Barley, Stephen. R. (1988a) Technology, power, and the social organization of work: towards a pragmatic theory of skilling and deskilling. Pp 33-80 in N. DiTomaso and S. Bacharach (Eds.) *Research in the Sociology of Organizations*. Volume 6. Greenwich, CT: JAI Press.

Barley, Stephen R. (1988b) The social construction of a machine: ritual, superstition, magical thinking and other pragmatic responses to running a CT scanner. Pp 497-539 in M. Lock and D. Gordon (eds.) *Biomedicine Examined.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Barley, Stephen. R. (1990) "The Alignment of Technology and Structure Through Roles and Networks" *Administrative Science Quarterly*, 35: 61-103.

Barley, Stephen R., John Freeman and Ralph Hybels. (in press) Strategic alliances in commercial biotechnology. In Robert Eccles and Nitan Norhia (eds.) *Networks and Organizations.* Boston, MA: Harvard Business School Press.

Barley, Stephen R. and Pamela Tolbert. (1990) Introduction: At the intersection of organizations and occupations. Pp 1-13 in P. Tolbert and S. R. Barley (eds.), *Research in the Sociology of Organizations*, Volume 8. Greenwich, CT: JAI Press.

Becker, Howard S., and Jame Carper. (1956) The development of identification with an occupation. *American Journal of Sociology*, 61:289-298.

Beniger, James R. (1986) *The Control Revolution: Technological and Economic Origins of the Information Society*. Boston: Harvard University Press.

Bishop, John H. and Shani Carter. (1991) The worsening shortage of college graduate workers. *Educational Evaluation and Policy Analysis*, 13:221-246.

Bluestone, Barry and Bennett Harrison. (1982) *The Deindustrialization of America.* New York: Basic.

Braverman, Harry. (1974) *Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century.* New York: Monthly Review Press.

Cambrosio, Alberto and Peter Keating. (1988) Going monoclonal: Art, science, and magic in the day-to-day use of hybridoma technology. *Social Problems,* 35: 244-260.

Carey, Max and Alan Eck. (1984) How workers get their training. *Occupational Outlook Quarterly.* Winter: 3-21.

Center for Advanced Human Resource Strategy. (1991) *Workplace 2000: An Adelphi Study.* School of Industrial and Labor Relations. Cornell University.

Coombs, R. W. (1984) Long-term trends in automation. Pp. 146-162 in Paul Marstrand (ed.), *New Technology and the Future of Work and Skills.* London: Francis Pinter.

Davis, K. and W. E. Moore. (1949) Toward a theory of stratification. *American Sociological Review.* 22:194-200.

Derber, Charles and William A. Schwartz. (1991) New mandarins or new proletariat?: Professional power at work. Pp. 71-96 in Pamela Tolbert and Stephen R. Barley (eds.), *Research in the Sociology of Organizations,* Volume 8. Greenwich, CT: JAI Press.

DiPrete, Thomas A. (1988) The upgrading and downgrading of occupations: Status definition and deskilling as alternative theories of change. *Social Forces,* 66: 725-746.

Drucker, Peter. (1979) Managing the knowledge worker. *Modern Office Procedures,* 24:12-16.

Durkheim, Emile. (1933/1893) *The Division of Labor in Society.* New York: Free Press.

Etzioni, Amatai. (1969) *The Semi-Professions and their Organization.* New York: Free Press.

Fink, James J. (1975) *The Car Culture.* Cambridge,MA: MIT Press.

Freeman, R. (1976) *The Overeducated American.* New York: Academic Press.

Franke, Walter and Irvin Sobel. (1970) *The Shortage of Skilled and Technical Workers.* Lexington, MA: Heath Lexington Books.

Freidson, Eliott. (1971) Professions and the occupational principle. Pp. 19-38 in E. Freidson (ed.) *The Professions and their Prospects.* Beverly Hills, CA: Sage.

Goode, William G. (1957) Community within a community: The professions. *American Sociological Review.* 22: 194-200.

Gorz, Andre (1976) Technology, technicians, and class struggle. Pp. 159-180 in A. Gorz (ed.) *The Division of Labor.* Atlantic Highlands, NJ: Humanities Press.

Greenbaum, J. M (1979) *In the Name of Efficiency.* Philadelphia, PA: Temple University Press.

Hall, R. H. (1968) Professionalization and bureaucratization. *American Sociological Review,* 33:92-104.

Harper, Douglas. (1987) *Working Knowledge: Skill and Community in a Small Shop.* Chicago: Chicago University Press.

Harris, Marvin. (1979) *Cultural Materialism: The Struggle for a Science of Culture.* New York: Random House.

Haug, Marie. (1973) Deprofessionalization: An alternative hypothesis for the future. Pp. 195-212 in P. Halmos (ed.), *Professionalization and Social Change.* Sociological Review Monograph, 20.

Hendry, Chris. (1990) New technology, new careers: The impact of company employment policy. *New Technology, Work and Employment.* X:31-43

Hounsell, David. (1984) *From the American System to Mass Production: 1800-1932.* Baltimore: Johns Hopkins Press.

Hughes, Everett C. (1958) *Men and their Work.* Glencoe, IL: Free Press.

Hughes, Thomas Parke (1983) *Networks of Power: Electrification in Western Society, 1880-1930.* Baltimore: Johns Hopkins Press.

Johnson, W. B. and Packer, A.H. (1987) *Workforce 2000: Work and Workers for the 21st Century.* Indianapolic, IN: Hudson Institute

Jordan, Kathleen and Michael Lynch. (1989) The sociology of a genetic engineering technique: Ritual and rationality in the performance of the "plasmid prep". Paper presented at the International Society for the History, Philosophy and Social Studies of Biology, London, Ontario.

Klein, D. P. (1984) Occupational employeemnt statistics for 1972-82. *Employment and Earnings,* 20: 13-16.

Kornhauser, William. (1962) *Scientists in Industry.* Berkeley: University of California Press.

Kraft, Philip. (1978) *Programmers and Managers: The Routinization of Computer Programming in the United States.* New York: Heidelberg Science Library.

Kurtz, R. and G. K. Walker. (1975) Test and pay technicians: Upward Mobility in Personnel. *Public Personnel Management,* 4:259-262.

Levin, H., and R. Rumberger. (1983) *Educational Implications of High Technology.* Stanford,CA: Institute for Research on Education Finance and Governance.

Majchrzak, Ann. (1988) *The Human Side of Factory Automation.* San Francisco: Jossey Bass.

Mallet, Serge. (1975) *The New Working Class.* Nottingham, Eng: Spokesman Books.

Marcson, Simon. (1960) *The Scientist in American Industry.* New York: Harper and Row.

Marx, Karl. (1970/1859) *A Contribution to the Critique of Political-Economy.* New York: International Publishers.

Merton, Robert K. (1960) The search for professional status: sources, costs and consequences. *American Journal of Nursing.* 60: 340-363.

Metz, Donald L. (1981) *Running Hot: Structure and Stress in Ambulance Work.* Cambridge, MA: Abt Books.

Miller, G. A. (1968) Professionals in bureaucracy. *American Sociological Review.* 32:755-768.

Nelsen, Bonalyn. (1991) Unpublished fieldnotes on technologically induced change in secretarial positions. School of Industrial and Labor Relations, Cornell University.

Olsen, Steve. (1986) *Biotechnology: An Industry Comes of Age.* Washington, DC: National Academy Press.

Orr, Julian E. (1990) Talking about Machines: An Ethnography of a Modern Job. Unpublished Doctoral Dissertation. Department of Anthropology. Cornell University, Ithaca, NY.

Orr, Julian E. (1991) Necessary or prescribed practices: An ethnographic approach to conflicting definitions of work and the realities of the job. Unpublished manuscript, System Science Laboratory, Xerox PARC. Palo Alto, CA: Xerox PARC

Pacey, Arnold (1983) *The Culture of Technology.* Cambridge, MA: MIT Press.

Parsons, Talcott. (1939) The professions and social structure. *Social Forces.* 17:457-467.

Parsons, Talcott (1968) Professions. Pp 536-547 in David Sills (ed.), *Encyclopedia of Social Sciences.* New York: Free Press.

Pelto, Pertti (1973) *The Snowmobile Revolution: Technological and Social Change in the Artic.* Menlo Park, CA: Cummings.

Peltz, Donald C. and Frank M. Andrews. (1966) *Scientists in Organizations: Productive Climates for Research and Development.* New York: Wiley.

Perrucci, R. and J. Gerstl. (1969) *Profession without Community.* New York: Random House.

Pettigrew, Andrew. (1973) *The Politics of Organizational Decision Making.* London: Tavistock.

Porat, Marc. (1976) *The Information Economy.* Unpublished Doctoral Dissertation. Palo Alto, CA: Stanford University.

Poulantzas, Nicos (1978) *Classes in Contemporary Capitalism.* London: Verso.

Price, Derek J. de Solla. (1986) Little Science, Big Science...And Beyond. New York: Columbia University Press.

Raelin, J. (1985) *Clash of Cultures.* Boston: Harvard Business School Press.

Ritti, R. R. (1968) Work goals of scientists and engineers. *Industrial Relations,* 7:118-131.

Ritti, R. R. (1971) *The Engineer in the Industrial Corporation.* New York: Columbia University Press.

Roberts, B. C., R. Loveridge, and J Gennard (1972) *Reluctant Militants.* London: Allen and Unwin.

Rumberger, Russell. (1986) Pp in Gerald Burke and Russel Rumberger (eds.) *The Future Impact of Technology on Work and Education.* Philadephia: Falmer Press.

Ruzic, Neil P. (1981) The automated factory. Pp. 165-173 in Tom Forester (ed.), *The Microelectronics Revolution.* Cambridge, MA: MIT Press.

Scott, William R. (1965) Reactions to supervision in a heteronomous professional organization. *Administrative Science Quarterly,* 10:65-81.

Silvestri, George and John Lucasiewicz. (1989) Projections of occupational employment: 1988-2000. *Monthly Labor Review,* 112:42-65.

Smigel, E. (1964) *Wall Street Lawyer: Professional Organizational Man.* New York: Free Press.

Smith, Chris. (1987) *Technical Workers: Class, Labour, and Trade Unionism.* London: MacMillan Education Limited.

Spangler, Eve. (1986) *Lawyers for Hire.* New Haven, CT: Yale University Press.

Spicer, Edward H (ed.) (1952) *Human Problems in Technological Change.* New York: Russell Sage Foundation.

Strauss, Anselm. L., Leonard Schatzman, Rue Bucher, Daniele Ehrlich, and Martin Sabshin. (1964) *Psychiatric Ideologies and Institutions.* Glencoe, IL: Free Press.

Teitelman, Robert. (1989) *Gene Dreams: Wall Street, Academia, and the Rise of Biotechnology.* New York: Basic Books.

Tonnies, Ferdinand. (1957/1887) *Community and Society.* East Lansing, MI: Michigan State University Press.

Toren, N. (1975) Deprofessionalization and its sources. *Work and Occupations.* 2:323-337.

U. S. Bureau of the Census. (1976) *The Statistical History of the United States from Colonial Times to the Present.* New York: Basic Books.

U. S. Department of Commerce. (1990) *Statistical Abstract of the United States.* Washington, DC: Government Printing Office.

van Maanen, John and Stephen R. Barley. (1984) Occupational communities: Culture and control in organizations. Pp. 287-365 in B. Staw and L. Cummings (eds.), *Research in Organizational Behavior*, Volume 6. Greenwich, CT: JAI Press.

von Glinow, M. A. (1988) *The New Professionals: Managing High-Tech Employees*. Cambridge, MA: Ballinger.

Weber, Max. (1968/1922) *Economy and Society*. G. Ruth and C. Wittich (eds). Berkeley, CA: University of California Press.

Whalley, Peter. (1986) *The Social Production of Technical Work: The Case of British Engineers*. Albany, NY: SUNY Press.

Wright, Erik Olin (1979) *Class Crisis and the State*. New York: Oxford.

Zuboff, Shoshana. (1985) Informate/Automate: The two faces of intelligent technology. *Organizational Dynamics*, Autumn: 5-18.

Zuboff, Shoshana. (1989) *In the Age of the Smart Machine*. New York: Basic.

Zucker, Lynne (1983) Organizations and institutions. Pp. 1-47 in Sam Bacharach (ed.), *Research in the Sociology of Organizations*, Volume 2. Greenwich, CT: JAI Press.

Zussman, Robert. (1985) *Mechanics of the Middle Class: Work and Politics among American Engineers*. Berkeley: University of California Press.

Table 1
Occupational Categories as a Percentage of the Labor Force: 1900-1988

Category	**1900**	**1910**	**1920**	**1930**	**1940**	**1950**	**1960**	**1970**	**1980**	**1988**	**Net Change**
Farmworkers	38%	31%	27%	21%	17%	12%	6%	3%	3%	3%	- 36%
Operatives/Laborers	25	27	27	27	28	26	24	23	18	16	- 9
Craft and Kindred	11	12	13	13	12	14	14	14	12	12	1
Service	9	10	8	10	12	11	12	13	13	13	4
Managerial	6	7	7	7	7	9	8	8	10	12	6
Sales Workers	5	5	5	6	7	7	7	7	11	12	7
Clerical and Kindred	3	5	8	9	10	12	15	18	17	16	13
Professional/Technical	4	5	5	7	8	8	10	14	15	16	12

Note: Percentage employment by occupational category from 1900 to 1970 was calculated from employment data presented on page 139 of *The Statistical History of the United States from Colonial Times to the Present* (U.S. Bureau of the Census 1976). Data for 1980 were taken from Klien's (1984) article which transforms 1980 data using the Census Bureau's category system developed in 1983. Data for 1988 are taken from the *Statistical Abstract of the United States* (U.S. Bureau of Commerce, 1990).

Table 2

Projected Growth in Occupational Categories: 1988-2000

Category	1988 Data: Employment in Thousands	1988 Data: Percent of Labor Force	Projected Growth Rate	Estimates for Year 2000: Employment in Thousands	Estimates for Year 2000: Percent of Labor Force
Farm Workers	3,058	3%	- 4.8%	2,911	2%
Operatives and Laborers	17,814	16	1.3	18,046	14
Craft and Kindred	13,664	12	9.9	15,016	11
Service	15,332	13	22.6	18,797	14
Managerial	14,216	12	22.0	17,344	13
Sales Workers	13,747	12	19.6	16,441	12
Clerical and Kindred	18,642	16	11.8	20,842	16
Professional/Technical	18,495	16	25.6	23,230	18
Total	114,968	100%	15.3	132,627	100%

Note: Employment Data for 1988 were culled from U. S. Department of Commerce, Statistical Abstract of the United States: 1990 Washington, DC: U. S. Government Printing Office. Projected Growth rates for 1988-2000 are those used by Silvestri and Lukasiewicz (1989).

Table 3
Characteristics of Professions, Crafts, and Technical Occupations

Attribute	Professions	Crafts	Technical Occupations
Skills and knowledge are possessed by people outside occupation.	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.	Basic skills and knowledge are widely held by persons outside the occupation. However, finesse is less widely distributed.	Knowledge and skills are esoteric. In some instances, amateurs may exist but, in general, they are relatively rare.
Importance of formal education as a means of training and socialization.	Most require either specialized undergraduate or graduate training. All require a college degree.	May require a formal apprenticeship. Otherwise, formal education is irrelevant.	Most require either a bachelors degree or a specialized associate's degree or its equivalent.
Importance of on-the-job training as a means of training and socialization.	Although informally important, clearly of secondary relevance	The primary avenue by which neophytes enter the occupation.	Frequently reported as a critical form of training. In some technical occupations, it is the primary form of training.
Balance of mental/analytic versus manual/sensate work.	Tasks are heavily weighted toward mental and analytic work.	Tasks are heavily weighted toward manual and sensate skills.	Tasks involve a heavy mental and analytic component, but the work also often has a significant manual or sensate component.
Evidence of formal occupational organization.	Professional societies, licensing, accreditation boards, professional journals are nearly universal.	Unionization common but not universal.	Mixed picture. Some technical occupations have journals and professional societies. Others have none.
Formal certification required to practice.	Yes	No	Common among technical occupations in medicine. Otherwise rare.
Other occupational means of controlling entry	High	Low - primarily through union control of apprenticeship programs	Low with the exception of technical occupation in medicine.
Autonomy over execution of work	High	High	High
Tendency to unionize	Low	High	Less common than among crafts, more common than among the professions.

Figure 1

Percentage Growth in Occupational Categories: 1950-88

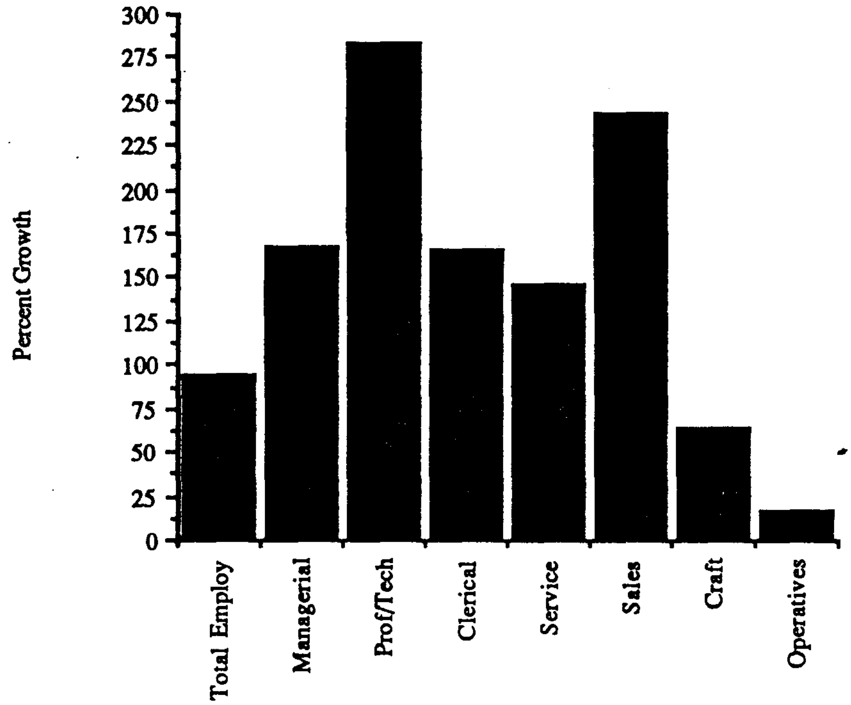

Figure 2

The Cybernetic Cycle

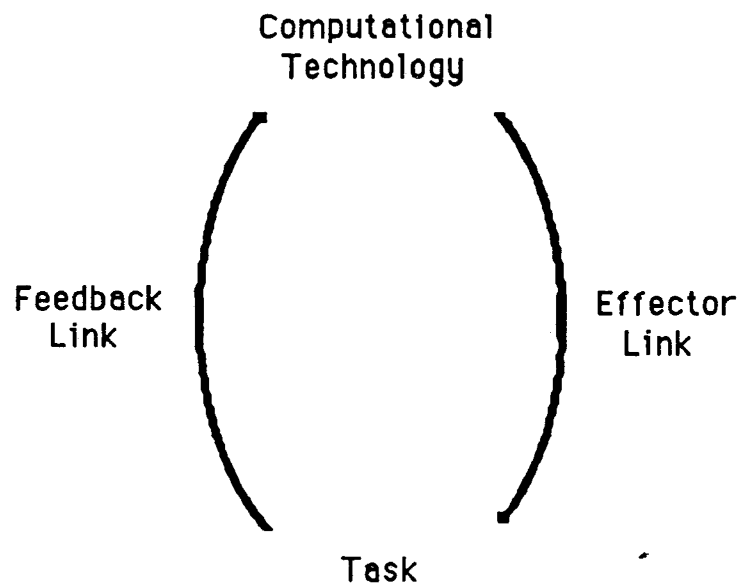

Figure 3

Occupational Categories Cross-Classified by Dimensions
Critical to Horizontal and Vertical Divisions of Labor

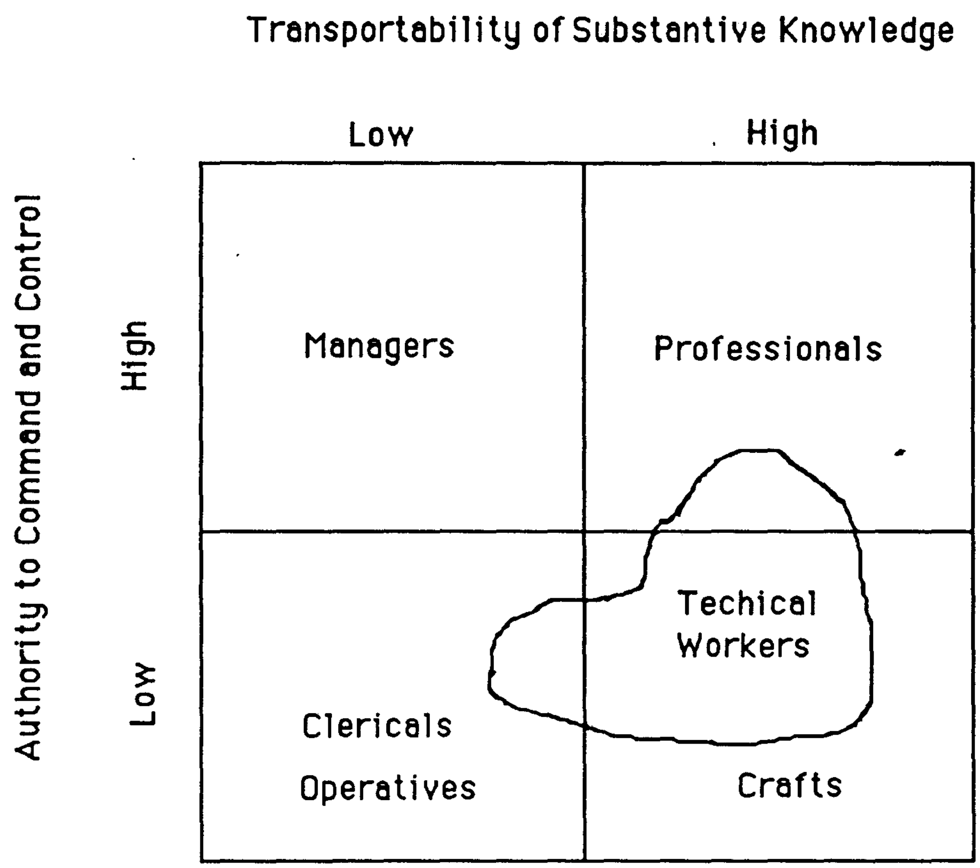

Figure 4

Research Design Matrix