Technological Change in an Auto Assembly Plant : The Impact on Workers' Tasks and Skills

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This article explores the impact of technological change and organizational restructuring on workers at the General Motors assembly plant in Linden, New Jersey. An in-plant worker survey was conducted as well as extensive interviews with workers, managers, and union officials. Changes in the plant polarized the work force: Skilled trades workers have experienced skill upgrading and gained more responsibility for maintaining and managing the new equipment, while production workers have undergone deskilling and find themselves increasingly subordinated to the new technology.

Technological Change in an Auto Assembly Plant

THE IMPACT ON WORKERS' TASKS AND SKILLS

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Against the background of current debates, this article presents a case study of the effects of technological change and organizational restructuring on workers' tasks and skills at the recently modernized General Motors assembly plant in Linden, New Jersey.[1] Our data indicate that the changes in this plant had highly polarized effects on the work force: Skilled trades workers experienced skill upgrading and gained enhanced responsibilities, while production workers underwent deskilling and became increasingly subordinated to the new technology. Reinforcing the turn in recent literature

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away from technological determinism and toward a "contingency" approach (Form, Kaufman, Parcel, & Wallace, 1988) that emphasizes the interaction between technological and social factors, we suggest that the skill polarization at GM-Linden resulted as much from the plant's organizational structure as from technological change itself.

Major concerns about new technology in the workplace fall into two categories: the labor-saving or job-destroying effects of computerization and automation, on one hand, and the effect of technological change on skill levels and other qualitative aspects of work, on the other. Here, we are interested primarily in the latter, especially the skill question, which has been debated for several decades now (see Form et al., 1988; Spenner, 1985, 1988). Even in the early commentaries, there were sharply conflicting claims, with some investigators arguing that technological change tended to reduce skill levels and others claiming that it led to skill upgrading. For example, Bright (1958) argued that automation was progressively removing skill and responsibility from the worker and investing it in machinery. In contrast, Blauner (1964), argued that the history of technology's impact on the quality of work followed a U-curve, with conditions at first deteriorating but later improving as more advanced technologies were harnessed by industry.

Debate about the qualitative impact of technology on work was renewed and intensified with the publication of Braverman's (1974) influential work and the critiques of it which followed (Wood, 1982). Braverman viewed technology as a tool of managerial control and argued (like Bright) that technological innovation increasingly removed skill from workers and placed it in the hands of managers. For Braverman, computerized technology (which was only in its infancy when he was writing) continued this historical deskilling tendency. Braverman's thesis was embraced by many other commentators on the impact of computerized automation on the workplace (Greenbaum, 1979; Noble, 1984; Shaiken, 1984).

Just before Braverman's book appeared, Bell (1973) asserted that new technology was leading to higher skill levels and that in postindustrial society, growing numbers of workers would become professionalized. More recently, variants of the postindustrial thesis have been adopted by a diverse group of commentators, who have argued that new technologies, together with the broader economic transformations of the 1980s, herald exciting new possibilities for work humanization and upgrading of skill levels (see, for example, Hirshhorn, 1984; Piore & Sabel, 1984; Zuboff, 1988). These authors have focused particularly on the *flexibility* of computerized technology, arguing, contra Braverman, that the rational use of flexible technology requires a break with the logic of deskilling that prevailed earlier in history, and corresponding organizational changes to increase worker participation in decision making and upgrade workers' skills and responsibilities.

A third position in the debate, associated particularly with Spenner (1983, 1985, 1988), is that technology has mixed and highly conditional effects on skill levels, and that while case studies may offer clear evidence of deskilling or upgrading, no firm conclusion about overall trends is possible. Based on an exhaustive review of the literature, Spenner (1985) concluded that "the impacts of technology on skill levels are *not* simple, *not* necessarily direct, *not* constant across settings and firms, and *cannot* be considered in isolation. . . . The same innovation in two different firms can alter skill requirements in different ways" (p. 146). This points to the "social and bureaucratic factors" shaping skill effects. Specifically, Spenner (1988) noted the key role of managerial discretion and organizational culture in conditioning the consequences of technological change for skill requirements. Similarly, Form et al. (1988) argued for a "contingency" approach to the study of technological impacts, viewing the impact of technology on work as "contingent on a set of organizational and societal variables that have not yet been adequately specified" (p. 311).

Both sides in the "deskilling versus upgrading" debate recognize, at least implicitly, the influence of organizational and social factors. We can illustrate this with a few examples that make reference to the U.S. auto industry. In a detailed case study of computerization in the tool and die shop at the Ford Rouge plant, Shaiken (1984), a supporter of the deskilling thesis, argued that the legacy of managerial distrust of workers there conflicted with the effort to improve efficiency. Because management was primarily concerned with enhancing its own control over tool and die makers' work and designed the technology with this goal in mind, the shop failed to achieve the productivity gains which the new technology might otherwise have made possible. Shaiken noted, "By embedding in the technology an effort to change the relations of power in the workplace, the potential value of the computerization was lost" (p. 216). He drew similar conclusions in another study (Shaiken, Kuhn, & Herzenberg, 1984) of the impact of robotization and computerization on production workers in the body shop of an auto assembly plant. Productivity and quality improved and some undesirable jobs were eliminated as a result of automation. Yet for many workers who remained, as well as first-line supervisors, there was "a significant deterioration in the work environment" and an intensification of work (Shaiken et al., 1984, p. 351). This was not an inevitable consequence of robotic technology itself, Shaiken and his colleagues argued, but rather was due to its design and application and the associated operating practices in this plant.

Evidence from the auto industry has also been marshalled to support the view that jobs are not deskilled, but rather upgraded, with automation. A case study of Ford's Dearborn engine plant, for example, found that while the number of production jobs was reduced substantially with automation, skill levels either stayed the same or increased:

> The task scope of the new machine operators . . . expanded as they took on responsibilities previously performed by other less-skilled workers and some additional learning was required. . . . Watching the control panel and reacting to various problems that occur in the day-to-day operation of the machines requires mental alertness and a specific knowledge of the peculiarities of each machine. (Chen, Eisley, Liker, Rothman, & Thomas 1984, p. 52)

Most commentators who support the upgrading thesis view the introduction of new technology in the auto industry as both facilitating and facilitated by a shift away from the traditional "Fordist" organization of production and toward a more flexible production regime which actively encourages the development of new skills in the work force (see Katz, 1985; Katz & Sabel, 1985; Tolliday & Zeitlin, 1986). In this vein, Piore and Sabel (1984) wrote optimistically about recent experiments in cooperation between the United Auto Workers (UAW) and the American auto firms:

> The hallmarks of the old system were narrow jobs, defined by precise rules, constantly amended by a highly developed system of procedural justice. The emergent system is based on broader job classifications, which reduce the number of distinct jobs and facilitate the transfer of workers from one task to another. . . . Thus, in the boldest experiments in which the UAW has participated, as many as sixty semiskilled production jobs have been grouped into a single classification. . . . Workers are paid for what they know—their skills—rather than what they happen to be doing—the job at the moment. (p. 244)

Our case study of the Linden GM plant offers no simple resolution of the debate about the impact of technological and organizational change on jobs and skills. However, it does support the emerging consensus that technology itself does not determine the nature of work experience and that technological change is inextricably intertwined with organizational factors. In this case, the plant's basic organizational structure remained largely intact, despite radical changes in technology. Under these conditions, the benefits of technological modernization were confined largely to the skilled trades, while production workers experienced some deterioration in the quaility of work and skills.

BACKGROUND

The auto industry is a world leader in the application of robotics and programmable automation, and has also experimented extensively with organizational changes. However, empirical research on how auto workers have been affected by and responded to these recent developments is surprisingly scarce. Even rarer are studies focusing on workers' perceptions of the changes. We conducted an in-plant worker survey as well as extensive interviews with workers, managers, and union officials in an effort to explore the impact of technological and organizational change on Linden-GM workers. The core of the analysis is based on workers' self-reported tasks and skills before and after the plant was modernized.

The Linden GM plant became one of the nation's most highly automated automobile assembly facilities after an extensive modernization in 1985-1986, making use of industrial robots and other forms of computerized manufacturing technology. Along with the technological changeover at Linden, GM introduced quality circles and a special training program for workers and supervisors to promote labor-management cooperation. However, unlike some other plants where radical reductions in numbers of job classifications occurred or where flexible work teams were introduced, Linden retains a fairly traditional organizational structure.

Until the fall of 1985, the Linden plant built large luxury cars—Cadilllac Sevilles and Eldorados, Buick Rivieras and Oldsmobile Toronados, also known as E and K cars. After the 1985-1986 changeover, the plant began making the much smaller and relatively inexpensive Chevrolet Corsicas and Berettas, the new L-cars. This major model change was the occasion for radical technological modernization. The 50-year-old plant was rebuilt from September 1985 to August 1986 at a cost exceeding $300 million. The body and paint shops were most dramatically transformed; the other major production departments—trim and chassis—still use relatively traditional technology, although they too were completely overhauled and their operations are now monitored and integrated by computer technology which is pervasive throughout the plant.

The most dramatic change was the introduction of robotics and automated guided vehicles (AGVs). There was one robot at Linden before the changeover; now there are 219, of which 192 are in the body shop (for welding), 12 in the paint shop, and 6 in the glass sealing cell. (The other 9 are used for training and as "spares.") There were no AGVs at Linden before; now there are 113, all in the body shop. The AGVs replace the fixed assembly line, carrying car bodies through the various stations. Directly associated with the robots is the extensive use of programmable logic controllers (PLCs), which program the robots' activities. Before the changeover, there were eight PLCs; now there are 186. In the body shop and in parts of the paint shop, Linden now uses parallel processing lines, with two identical stations operating side by side (Gabriele, 1987).

There have also been a number of important organizational innovations at Linden since the changeover, although the labor agreement is traditional (with numerous job classifications) and the plant has not moved to the team system. In regard to work organization, the major changes include (a) the introduction of the build-in-station and stop-the-line concepts, which encourage quality control at all phases of the production process; (b) the resulting elimination of many repair jobs; (c) a shift from tag to mass relief, so that all workers have their breaks at the same time; (d) the introduction of Japanese-style "just in time" delivery systems and statistical process control; and (e) extensive job rearrangement for the new technology. There have also been changes in the industrial relations system, most notably an increased emphasis on improved communication and "jointness" and the introduction of employee involvement groups.

THE EMPLOYMENT IMPACT

As with previous forms of automation, many existing jobs are inevitably eliminated with application of the new computerized technologies. In the automobile industry as a whole, job losses in recent years have been massive: Employment in the U.S. motor vehicle industry (including parts suppliers) fell 194,600 between the December 1978 peak and February 1988, a decline of 23.4% (U.S. Bureau of Labor Statistics, various years). However, it is difficult to ascertain the extent to which automation and computerization have contributed to the job loss. Other major factors in the erosion of jobs in the industry include the loss of market share by domestic producers to foreign producers, importing of cars by domestic producers, and outsourcing of components production. Certainly, some jobs have been eliminated due to new technology, but it is virtually impossible to obtain precise figures (see, however, estimates in Ayres & Miller, 1982, p. 42; Hunt & Hunt, 1983, pp. 169-172).

As one might expect, substantially fewer people are now employed at the Linden GM plant than prior to the 1985-1986 changeover. This would have occurred even without the extensive introduction of new technology, because the E-K cars made at Linden before the changeover were larger and had more parts than the L-cars that replaced them. The number of production workers in the plant dropped by 26% – from 4,460 in September 1984 to 3,283 in December 1987, according to the UAW Research Department and local management. The number of first-line supervisors fell even more: from 156 in July 1985 to about 90 three years later – a drop of 42%.[2] There was also a drop in the total number of salaried workers, which fell 28% – from 608 in August 1985 to 437 in August 1987.

The only exception to this pattern of reduced employment was the skilled trades work force (electricians, carpenters, machinists, and so on). Their numbers *rose* dramatically from 235 in September 1984 to 425 in December 1987, an 81% increase. Even as the overall size of the work force fell, the skilled trades rose both absolutely and as a proportion of the total. This was because, with the introduction of new, technologically complex machinery, demands on the plant's skilled maintenance staff increased dramatically. (A study of another auto plant modernization found similar results; see Miller & Bereiter, 1985). While prior to the modernization, all the skilled trades workers were in one department (called "maintenance"), now these workers are assigned to specific areas. The plant is divided in half by a railroad track, with the trim and chassis areas on one side and the body and paint shops on the other. In our fieldwork, we frequently heard workers and managers refer to the "traditional" and "high-tech" sides of the plant. The division of labor among skilled trades workers follows that pattern. There is a separate department for the body shop maintenance workers, and a small group of tradespeople are assigned to the computer measuring machine (CMM) room. We will refer to these two groups as the "high-tech maintenance" workers. Slightly over half the skilled trades workers, however, remain in the general maintenance area, using and maintaining relatively traditional technology. They are referred to here as "traditional maintenance" workers (following the terminology used at Linden).

The changes in employment levels were not evenly distributed through the plant, as Table 1 shows. There were changes in both "direct labor," which is the labor directly involved in putting the car together, and "indirect labor," which is other blue-collar work, such as the skilled trades' maintenance of the plant's machinery and equipment and various nonskilled jobs like cleaning the plant, receiving parts, and delivering them to various areas of the shop. As the table shows, while direct labor declined by 36% between 1985 and 1987, indirect labor rose 7%, reflecting the increase in skilled trades employment already noted. Offsetting that increase, however, was a sharp decrease in employment in the material department (where stocks of parts are kept),

TABLE 1: Linden Employment Levels, Before and After Changeover, by Department, August 1985 and December 1987

	August 1985		*December 1987*		*Change from August 1985 to December 1987*	
	(A) Number of Workers	*% of All Direct Labor*	*(B) Number of Workers*	*% of All Direct Labor*	*(B – A) Absolute Change*	*(B – A)/A Percentage Change*
Direct labor						
Body shop	568	14	385	15	–183	–32
Paint shop	681	17	520	20	–161	–24
Trim department	1,385	34	779	30	–606	–44
Chassis department	1,020	25	755	29	–265	–26
Inspection	425	10	177	7	–248	–58
Direct labor subtotal	4,079	100	2,616	100	–1,463	–36
Direct as % of total	82		73			
Indirect labor						
Material[a]	319		230		–89	–28
Maintenance, unskilled	174		173		–1	–0.6
Maintenance, skilled	278		404		+126	+45
Other indirect[a]	114		137		+23	+20
Indirect labor subtotal	885		944		+59	+7
Indirect as % of total	18		27			
Grand total	4,964		3,560		–1,404	–28

SOURCE: Computed from "GMAD Linden Force Report," August 30, 1985, Shifts 1 and 2; "1988 Model Authorized Manpower @ 60 jph - A.D.A.M.," December 14, 1987; and "1987 Indirect Labor Summary," December 1, 1987. These documents were supplied by local plant management.

a. Includes some skilled trades workers. In December 1987, 16 of the 230 workers in the material department and 30 of the 137 in the "other indirect labor" category shown here were skilled trades workers. Figures on this for 1985 were not made available to us.

due to both the smaller number of parts in the L-car compared to the old E and K models, and the introduction of a "just in time" inventory system that reduced inventory levels (and thus labor requirements in the material department).

Table 1 also shows that within the direct labor category employment reductions varied by department, although in every category there was a substantial decline, reflecting the new technology, the change in car model, and the organizational changes introduced with the modernization. The most dramatic case is that of the inspection department, in which employment was cut by 58%. This reflects the introduction of the build-in-station concept, whereby operators inspect their own work. The second largest decline in direct labor was in the trim department, due mainly to the change in the type of car produced at Linden. While in 1985 the plant manufactured Cadillacs and other luxury cars with many options and much more complex interior (trim) assembly, the L-cars are relatively simple to build. Some automation was also introduced in the trim department, but this was a relatively minor factor. The decline in the labor requirements in the chassis area (26%), similarly, reflects primarily the change in the car models being produced. By contrast, the declines in body (32%) and paint (24%) were due primarily to the new technology. It appears that the change in car model actually had a greater impact on employment levels than the technological changeover itself.

While since the changeover there has been some consolidation of production workers into fewer classifications, accompanied by declines in the population of other classifications, this has not been the case in the skilled trades. The only striking change there has been the enormous expansion in the number of electricians (from 28 in September 1984 to 154 in December 1987). This is mainly due to the extensive hiring of robot repair workers and other personnel to maintain the new equipment in the body shop. There have been modest increases in employment in several other trades since the changeover as well.

METHOD

Extensive interviewing of workers (in groups and individually), managers, and union officials, together with an in-plant survey conducted in early 1988 provided revealing data on the effects of the changeover on Linden's work force.[3] Unfortunately, it was not possible to conduct a longitudinal study with independent measures of tasks and skills taken before and after the technological change; rather, the survey was retrospective, with each respondent reporting on both the pre- and postchangeover situation. Although workers seemed to have remarkably vivid memories of their earlier job experiences, we cannot rule out the possibility of some retrospective bias in the results. Also, the absence of workers who were employed at Linden before the changeover but were no longer employed there at the time of the survey may have produced some bias in the sample, although we have no reason to think that workers' representations of job tasks and skills would have been substantially different for this group.

The sample, which included 217 production workers and 52 skilled trades workers, was drawn from a list of first (day) shift hourly workers provided by local management. Because we wanted data on each production department and on the skilled trades, we drew a two-stage stratified sample for the study, oversampling some groups and including only workers who worked at Linden in the same department before and after the changeover.[4] The production workers were drawn from the four main production departments in the plant, with approximately 55 each from the body, paint, trim, and chassis departments. (Workers in the material and inspection departments were not included in the sample.) The skilled trades workers were drawn from both the traditional and the high-tech skilled trades departments, with slightly more than half of the respondents in the traditional department. Within each category of workers included in the survey, we drew a simple random sample from the population of workers who were employed in the same department of the plant before and after the changeover. Complete questionnaires were obtained (in face-to-face interviews, with the interviewer recording responses) from 90% of the workers in the stratified sample. Of the remainder, over half were on medical or personal leave at the time of the survey, and two individuals (1% of the sample) were union committeemen and therefore ineligible respondents. Only 12 people (4% of the sample) refused to be interviewed.

SURVEY RESULTS

Workers who participated in the survey were asked how much the technology introduced in the plant since the changeover had affected their work. Among the skilled trades respondents, about half (51%) said that their work had been affected "a lot" by the new technology, compared to about one third (32%) of the production worker respondents. However, as Table 2 shows, there were significant differences within each group. As one would expect,

TABLE 2: Percentage of Respondents Who Said Their Work Had Been Affected "a Lot" (compared to "a Little" or "Not at All") by the New Technology, by Department

	Percentage Response
Skilled trades*	
High-tech	70
Traditional	36
Production workers**	
Body	47
Paint	33
Trim	24
Chassis	23

*Comparison of traditional and high-tech skilled trades significant at .05 level ($\chi^2 = 5.79$).
**Comparison across all production departments significant at .05 level ($\chi^2 = 9.64$).

both skilled trades and production worker respondents in the plant's high-tech areas reported greater effects on their work than those in the more traditional areas. The workers who reported the strongest effects of technology were the high-tech skilled trades workers who are responsible for maintaining the plant's new equipment in the body shop and the CMM room. Body shop production workers had the next highest rate, followed by traditional maintenance workers and paint shop production workers. As one would expect, trim and chassis production workers reported much weaker effects of the new technology, with over half of the respondents in both departments reporting that their work had not changed at all as a result of the new technology.

Technology affects skilled trades workers and production workers in distinct ways because the work of these two groups is so different. The skilled trades workers are much more likely to use new technology, especially computers, than are production workers. In addition, the presence of new equipment in the plant means that skilled trades workers must learn how to maintain that equipment. While this latter dimension affects primarily the high-tech maintenance workers assigned to the body shop, the use of technology as a tool seems to involve traditional maintenance workers almost as much as their high-tech counterparts. In our survey, 45% of traditional and 52% of high-tech skilled respondents reported that they use a computer in their work, compared to only 5% of production worker respondents. Those skilled trades workers who use computers (mainly electricians) spend a lot of time doing so: an average of 2 hours per day for traditional and 3 hours per day for high-tech maintenance workers. In both cases, the computer is typically a PLC, used mostly for programming and troubleshooting.

While both skilled trades groups *used* technology frequently, the high-tech skilled trades workers were much more likely to be responsible for *maintaining* such equipment as robots, AGVS, or lasers than were traditional maintenance workers. Fully 57% of the high-tech skilled trades respondents are involved in robot maintenance, compared to 21% of the traditional skilled trades. Similarly, 13% of the high-tech trades respondents maintain AGVs, compared to 3% of those in the traditional department. Laser equipment is maintained by 31% of the high-tech respondents, compared to 10% of the traditional group. (The numbers of respondents on which these percentages are based are very small—for example, the 3% refers to one person; so that these figures lack great precision. But they do suggest the general contrast between the two groups.)

Among production workers, the extent of automation reported differs along predictable lines. When respondents were asked, "Is any of the work you did before the changeover automated now?", those in the body and paint departments were much more likely to answer affirmatively than those in trim and chassis: 45% of body shop and 38% of paint shop respondents said yes, compared to 15% of chassis and 6% of trim department respondents.

At Linden, the transformation of job content since the changeover and the resultant skill mixes have been highly uneven, with large variations among departments and between production workers and the skilled trades. However, two basic generalizations emerge from the data. First, the change in the task composition of jobs for both production workers and the skilled trades has been relatively modest. Although many production jobs have been eliminated, the content of those that remain is not dramatically different from before. Similarly, while they have increased in number and complexity, the basic task content of the plant's skilled trades jobs has changed relatively little, with troubleshooting and repair of equipment still constituting the dominant activities. The only striking job content change among skilled trades workers is a sharp increase in programming activity.

The second generalization involves changes in skill levels. Most broadly, skill requirements have gone up for workers at Linden, in that, as shown earlier, the ratio of skilled trades to production jobs has increased. The data also show that the skill requirements of maintenance jobs have increased since the changeover. However, production jobs tend to be *less* skilled than before, partly because the new technology eliminated many of the most demanding jobs, and partly because management abolished tag relief and reduced the amount of repair work.

CHANGES IN JOB CONTENT

Survey questions on job content permit analysis of the direction of task reallocation as perceived by workers. Tables 3 and 4 summarize the data on the tasks performed by production and skilled trades workers. The last column of each table indicates the proportion of workers who identified each task shown as part of their job before and after the changeover. This generates a profile of the overall changes in the composition of work tasks for both skilled trades and production workers.

Table 3 indicates that the task elements of production workers' jobs have been altered only marginally. Using tools, performing assembly work, and handling parts were the most commonly reported tasks before the changeover as well as after, although these three elements are a significantly smaller proportion of post- than prechangeover job content. Inspection work was also performed by a large proportion of workers before the changeover, and it too was reported to be significantly less important in the postchangeover period. Much larger reductions occurred in three types of tasks as a result of the organization changes that took place in the plant:

1. Subassembly work was drastically reduced, largely because of the shift to a smaller car with fewer parts.
2. With the elimination of the relief classification, training new workers was performed by many fewer respondents than before.[5]
3. Due to the new practice of returning defective components to vendors and the build-in-station concept, repair work was substantially reduced.

The other task that declined significantly for production workers was clamping. In general, as Table 3 shows, the task content of production workers' jobs as well as the diversity of tasks performed have diminished since the changeover. The only exceptions are machine monitoring and loading, which gained slightly.

Table 4 on skilled trades workers is similar to that for production workers in that it shows only modest changes in the overall distribution of job tasks. However, for the skilled trades, the task content of jobs increased, in sharp contrast to the trend for production workers. While the two most frequently mentioned tasks, troubleshooting and repairing equipment, declined slightly (and statistically insignificantly) in importance, every other task shown was reported to have increased among skilled trades respondents. The most dramatic change was the 127% rise in programming, but training new workers, machine monitoring, and diagnostic work, as well as the making of parts also increased modestly.[6]

TABLE 3: **Production Workers' Tasks Before and After the Changeover, by Department (in percentages)**

	Body Shop		*Paint Shop*		*Trim Department*		*Chassis Department*		*All Production Departments*	
Task	*Before*	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*
Tool use	82	76	72	67	94	83*	89	83	84	77**
Assembly work	82	69*	32	32	89	85	87	83	72	67*
Parts handling	71	69	35	9***	91	83	91	76**	72	60***
Inspection	44	53	61	50*	43	30	43	33	48	42*
Subassembly work	27	33	19	9**	50	22***	54	19***	37	21***
Training	69	40***	56	41**	57	26***	57	37**	60	36***
Repair	47	33**	57	50	46	24***	41	30	48	34***
Machine monitoring	15	29*	22	17	15	20	20	22	18	22
Clamping	56	42	6	0*	30	9***	35	30	32	21***
Machine loading	24	46***	13	0***	2	4	15	2	14	15
Machine unloading	18	29	11	0**	2	9	13	11	12	12
Welding	49	35*	2	0	0	2	0	4	13	10
Minor machine maintenance	7	18*	20	15	2	0	9	6	10	10

*p < .10; **p < .05; ***p < .01, all one-tailed paired *t* tests.

TABLE 4: Skilled Trades Job Tasks Before and After the Changeover, for Traditional and High-Tech Workers (in percentages)

	Traditional		*High-Tech*		*All Skilled Trades*	
Task	*Before*	*After*	*Before*	*After*	*Before*	*After*
Troubleshooting	79	76	91	91	85	83
Repairing equipment	86	86	83	74	85	81
Diagnostic work	59	69*	74	82	65	75**
Monitoring machinery	55	62	65	74	60	67
Training new workers	41	59	44	48	42	54
Making parts	41	52*	44	39	42	46
Programming	21	35**	17	52***	19	42***

*$p < .10$; **$p < .05$; ***$p < .01$, all one-tailed paired t tests.

The picture becomes considerably more complex, however, when these changes in job content are disaggregated, revealing how different departments of production and skilled trades workers were affected. Let us begin with the production workers. Table 3 shows the changes in task content for each of the four production departments surveyed. What is most striking is that in many instances the changes in the body shop run counter to the overall trends. For example, subassembly, which declined significantly in the other three departments, rose in importance in the body shop (although the rise is not statistically significant). Loading machines became significantly more common in the body shop, while in paint it declined. Minor machine maintenance also rose significantly in the body shop, while declining (insignificantly) elsewhere in the plant. Machine monitoring rose in every department but paint; however, only in the body shop was the change statistically significant, with monitoring almost doubling in reported frequency. On the other hand, assembly work and welding declined significantly only in the body shop—where welding had previously been most extensive.

These changes in the makeup of body shop tasks primarily reflect the extensive introduction of robotic technology. Robots now perform many welding tasks and also eliminated the need for some clamping. A higher proportion of workers' tasks are ancillary to the machinery than before: Loading and unloading machines, monitoring machines, subassembly (which frequently involves feeding subassembled items to the machines on the line), minor machine maintenance, and inspection are examples of tasks of this type, all of which became more common after the changeover among body shop workers.

In the paint shop, the other high-tech area of the plant, the data show a general decrease in the variety of tasks performed. Every single task shown in Table 3 declined in importance in the paint department, except for assembly work, which was unchanged. Particularly dramatic was the decline in parts handling, cut by nearly 75%, and subassembly, which fell over 50%. Other tasks indirectly involving parts handling, such as clamping and machine loading and unloading—none of which had ever been very important in the paint shop—now vanished completely from it. This reflects the lower complexity and unibody design of the L-cars, as compared to the old E-K models. While training new workers, inspection, and repair work also declined after the changeover, they remain more widespread in the paint shop than in any other production department surveyed.

Different kinds of changes occurred in the two general assembly departments: trim and chassis. The sharpest declines were in subassembly work and in training new workers, primarily because of the shift to a smaller car model with many fewer parts. For the same reason, clamping and tool use became much less important in the trim department, while parts handling fell in chassis. Repair work also fell sharply in trim, reflecting the new policy of sending defective components back to the vendor rather than repairing them on the line as was done before the changeover. (All of these changes were statistically significant.)

As Table 4 shows, among skilled trades workers, there were also striking differences in task allocation among different departments; however, due to the small size of the sample, few of the changes are statistically significant. Both traditional and high-tech skilled trades workers appear to have experienced substantial changes in work content. In both cases, but especially for the high-tech maintenance workers, who are now responsible for the care of the robots, AGVs, lasers, and other new equipment, the increase in task content is notable. The only tasks reported to be less frequently performed by high-tech workers after the changeover are repairing equipment and making parts. This reflects two changes in the work of the skilled trades in the body shop. One is that some skilled trades workers are now dedicated to the monitoring of particular equipment on a full-time basis, while others do the actual repair work. In addition, some of the new electronic equipment can be manipulated with computers (PLCs), reducing the need for hands-on repair work or parts making. This affects electricians particularly—the largest high-tech trades group.

On the traditional side of the plant, the work of the skilled trades has changed less, given the more modest changes in technology outside the body shop. Millwrights, machinists, and pipefitters here perform essentially similar tasks despite the changeover. However, even on the traditional side, the survey found substantial increases in task content among skilled trades workers. Reflecting the computerization of the entire plant, diagnostics and programming became much more important components of traditional skilled trades work, although in the case of programming, the increase was considerably less for traditional than for high-tech skilled trades workers.

The work of electricians has been altered more than that of any other skilled trade. While before, electricians spent a lot of time doing work by hand, they now can use PLCs to manipulate electrical flows. Similarly, they now build circuits by pushing buttons rather than manually and use computers to troubleshoot instead of physically operating electrical switches. Electricians on both the traditional and the high-tech side of the plant must now have both traditional electrical skills and modern electronic know-how. While electricians are the extreme case, jobs appear to be broader than before the changeover for most skilled trades at Linden, although the data are not conclusive.

CHANGES IN SKILL LEVELS

Job content and skill levels, while closely interconnected, are distinct dimensions of work. The tasks involved in a job can increase or decline without necessarily altering its skill level. However, our findings on task changes in the previous section closely parallel the survey data on skill levels, which show an overall decline in skill for production workers and an increase for the skilled trades. The basic data are summarized in the last columns of Tables 5 and 6, which show the percentages of production and skilled trades respondents who indicated that the skills shown were "very important" in their jobs both before and after the changeover. (Other possible responses were "not important at all," "not very important," and "fairly important.") In all 12 skill areas investigated, production workers reported diminished skill levels after the changeover. In many cases these changes were small, but all but four of them are statistically significant. In sharp contrast, skilled trades workers reported an increase in every skill area except one (physical strength). The magnitude of these changes tended to be larger, although due to the small sample size, many were not statistically significant.

The decline in production workers' skill levels was generally consistent across all four departments surveyed, as Table 5 shows. In the body shop, while most of the changes are not statistically significant, the only exception to the deskilling tendency was that problem solving was considered "very important" after the changeover by 34% of respondents, compared to 25%

TABLE 5: Percentage of Production Workers for Whom the Skills Shown Were "Very Important" to Their Jobs, Before and After the Changeover, by Department

	Body Shop		*Paint Shop*		*Trim Department*		*Chassis Department*		*All Production Departments*	
Skill	*Before*	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*
Accuracy/precision	70	68	70	61	70	63	72	61	71	63*
Speed	70	62	44	46	67	63	56	56	59	57
Concentration	62	48*	54	48	59	43**	56	54	58	48***
Judgement	62	49	61	44	57	50	48	44	57	47***
Memory	55	36**	61	44**	70	44***	67	43***	63	42***
Ability to communicate clearly	47	42	39	28*	52	33**	44	48	46	38**
Problem solving	25	34	42	33	44	43	54	37**	41	37
Knowing how your department works	51	36*	52	33***	56	41**	46	33*	51	36***
Knowing about tools and machines	55	47	46	35*	47	30**	40	28	47	35***
Physical strength	57	55	32	13***	33	39	41	32	41	34*
Reading/spelling	13	11	10	6	20	17	24	22	17	14
Knowledge of math	9	4	4	4	7	2*	13	15	8	6

*$p < .10$; **$p < .05$; ***$p < .01$, all one-tailed paired t tests.

TABLE 6: Percentage of Skilled Trades Workers for Whom the Skills Shown Were "Very Important" to Their Jobs, Before and After the Changeover, by Department

	Traditional		*High-Tech*		*All Skilled Trades*	
Skill	*Before*	*After*	*Before*	*After*	*Before*	*After*
Knowing about tools and machines	76	83	83	87	79	85
Memory	66	79**	44	83***	56	81***
Accuracy/precision	41	55	52	96***	46	73***
Problem solving	48	59	57	91***	52	73***
Judgement	62	59	78	87	69	71
Ability to communicate clearly	38	55*	61	65	48	60*
Concentration	35	48	52	74*	42	60**
Creativity	28	31	35	52	31	40
Speed	28	31	35	44	31	37
Reading/spelling	24	28	22	35*	23	31
Knowledge of math	21	21	13	17	17	19
Physical strength	21	10*	22	22	21	15

*$p < .10$; **$p < .05$; ***$p < .01$, all one-tailed paired *t* tests.

before the changeover. Although not statistically significant, this change reflects the relatively extensive involvement of body shop workers with new technology. In the paint shop and trim department, the general deskilling pattern is more strongly in evidence: More of the skills shown declined significantly. Finally, in the chassis area, there were fewer significant changes, but once again, most skills were reported to have declined. Overall, there is an unmistakable deskilling tendency in all four departments.

Confirming this finding that skill levels have declined are the survey data on how much time workers say it would take for newcomers to learn to do their job well. For production workers, the median figure given was 5 days before the changeover and 3 days afterward. In the paint shop, however, the median (5 days) was the same before and after the changeover, while in the other departments, it declined.

Several factors contributed to the reduction in skill levels for production workers. Two of the most important were the elimination of tag relief and the new practice of sending defective parts back to vendors rather than repairing them on the line. These changes meant that the plant had far fewer workers in two relatively skilled production classifications—relief, which demands the ability to perform a large number of different jobs, and repair work, which inherently requires greater skill than most production-line jobs. While there are still a few relief workers in the body shop, and some Linden workers still engage in repair activity, both functions have been dramatically reduced since the changeover. The workers affected clearly perceived these changes as a decline in skill. As one worker who used to do repair work but now sends defective parts back to the vendor put it, "They are basically taking my skill away from me. I'm not a repair man or a specialist. I'm just a parts changer."

New technology has also contributed to the reduction in skill requirements for production workers. In the body shop, for example, the need for manual soldering and welding has been greatly reduced. "Not too many fellows could do the [soldering] job," one body shop worker recalled. "You had to be precise, because you had to put only so much material – lead – on the job." While a few production workers now use computers as a by-product of technological modernization, some expressed skepticism as to whether this constituted an increase in skill. As one operator noted "There is nothing that really takes any skill to operate a computer. You just punch in the numbers, [and] the screen will tell you what to do. It will tell you when to race the engine and when to turn the air conditioner off – when to do everything. It's very simple."

The reduced number of parts in the L-car as compared to the E-K model also contributed to the diminution of production worker skill levels, especially in the trim area. "In the last model, I had the feeling it involved more craftsmanship than building this kind of car," one trim worker told us. "[Now,] there is very little hands-on craftsmanship. . . . These units are flying down the line real fast."

It is important to recognize that many production workers' jobs in automobile assembly plants have always been highly routinized, with relatively limited skill requirements; for many production workers at Linden, this situation has not been altered since the changeover. Indeed, when asked directly whether their work requires more, less, or about the same skill as before the changeover, the majority of production worker respondents (53%) said "about the same skill." The others were split between "less skill" (27%) and "more skill" (20%), with only marginal differences among the various production departments surveyed. It is interesting that responses to questions about changes in *specific* skills suggest a much stronger deskilling tendency. Of course, specific skills other than those we investigated may have increased in importance following the changeover, which would explain the disparity between the general and the specific data. Also, some workers may prefer not to acknowledge that their skill levels have declined when asked the question in its most direct form.

The situation of skilled trades workers at Linden is exactly the opposite of that of production workers: There is marked upgrading in skills, a direct by-product of the introduction of new technology into the plant. Indeed, as Table 6 shows, upgrading has been much more extensive for high-tech maintenance workers than for skilled trades on the traditional side of the plant. In particular, such abstract skills as memory, accuracy, concentration, and problem solving have increased dramatically (and significantly) for high-tech workers, as have reading and spelling skills (for similar results among office workers, see Pullman & Szymanski, 1986). However, for the traditional skilled trades, skill increases have been more modest, and in most cases statistically insignificant.

Asked to characterize the extent to which they found their work challenging before and after the changeover, nearly two thirds (63%) of all skilled trades respondents said it was "more challenging" now, almost none (4%, or 2 respondents) said it was "less challenging," while the rest indicated that it was "about the same." The high-tech maintenance respondents were the most emphatic, with 73% saying that their work was more challenging now, compared to 55% of the traditional maintenance respondents. Similarly, skilled trades workers reported that the amount of time needed to become proficient at their jobs (not including the training and experience they must have before being hired by GM) had doubled—from a median of 6 months before the changeover to 12 months now. Still another indication of the upgrading of skill levels among the maintenance work force is the extensive, highly technical training they received during to the changeover—an average of 48 full days' worth. This amount of training was 10 times that received by production workers, much of which was motivational rather than technical. Despite the lengthy training, a large majority of the skilled trades respondents (71%, and 87% of the high-tech respondents) said they would benefit from additional training. By contrast, less than one tenth of the production workers felt they needed more training.

Skilled trades workers repeatedly emphasized that the knowledge needed to maintain the plant equipment had greatly increased since the changeover, particularly on the high-tech side of the plant. "You find that every robot is different," one machinist told us. "You have special tools that have to be used with each individual robot. The whole sequence of putting them together and taking them apart is entirely different." An electrician agreed: "Each robot has its own personality, so the longer you work here, the better you get to know the robot. . . . [With] each one, you learn its bad habits." Skilled trades workers were also acutely conscious of the fact that the high-tech equipment had increased their level of responsibility as well as skill. "You have to know what all the keys stand for [on the computerized equipment]," one electrician pointed out. "You push the wrong button, you make a big fat mistake — you can cause a disaster."

CONCLUSION

Neither upgrading nor deskilling models fit Linden GM. On one hand, the proportion of skilled jobs among all blue-collar jobs in the plant rose, which some might interpret as upgrading. On the other hand, the sort of polarization predicted on the macro level by the deskilling model occurred here *within* a single factory. A preexisting cleavage in the work force between skilled trades and production workers was magnified by technological change. Skilled trades workers (always the elite of the auto industry's blue-collar work force) experienced substantial upgrading, while production workers, whose prechangeover jobs were already the paradigmatic case of deskilled and degraded work, either stayed at the same low skill level or endured further deskilling.

This case supports the "contingency" model of technological change (Form et al., 1988) and Spenner's (1988) emphasis on the importance of managerial discretion and organizational culture in shaping the outcomes of technological change. Our evidence suggests that the skill polarization of the work force at GM's Linden plant was as much a product of organizational factors as of the technology itself. A number of specific factors were important here. The coincidence of the technological renovation with a shift from large to small car production helped shape the outcome through a simpler product with fewer parts. The adoption of Japanese-inspired techniques, designed to improve product quality by reducing the amount of repair work done in the plant, also eliminated some of the more highly skilled production jobs that had existed before the changeover.

Most important was the *absence* of any change in the basic division of labor between the skilled trades and production work force. The relationship of each group to technology was preserved intact. In the aftermath of the changeover, as had been the case historically, production workers remain in many respects *subordinated to* the equipment, while the role of the skilled trades workers (as it was before) is to maintain and *manage* the machinery. This organizational inertia, combined with a shift to new, more complex technology, magnified the preexisting skill differences in the work force.

NOTES

1. For a more extensive report on the findings of this study, see Milkman and Pullman (1988).

2. First-line supervisors include all plant foremen but not superintendents, production coordinators, or other shop floor management. These data and others cited in this paragraph do not perfectly correspond with the dates for the before and after figures. Local management was unable to provide us with fully comparable longitudinal data on these different groups of workers.

3. The survey was jointly designed by the authors and administered by them together with a group of graduate students from the City University of New York.

4. Skilled trades workers were overrepresented in the survey sample relative to the plant population: The 52 skilled trades workers interviewed comprised 19% of the respondents, but the 439 skilled trades people in the plant comprised 11% of the Linden work force. Oversampling the skilled trades was deliberate: The objective was to have a large enough group of skilled trades respondents to permit comparison of their responses to production workers'. Some production departments were also oversampled to facilitate comparisons between the two high-tech departments—the body and paint shops—in which employment levels are relatively low, and the two departments using more traditional technology, namely, trim and chassis. Although only 13% of the production work force at the Linden plant is in the body shop, 25% of the production workers who responded to the survey are in that department. Similarly, although only 18% of the plant's workers are in the paint shop, 25% of the production worker respondents are located in that department. By contrast, the trim and chassis departments are each about 25% of the plant population and also about 25% of the sample. (The balance of the plant population is in departments that were not sampled, such as material and inspection.)

5. While current utility workers were excluded from the sample, among our respondents were several workers who were formerly utility or relief workers. The sharp decline in training shown here, therefore, may be partly an artifact of the sample selection process.

6. The increase in training appears quite large and yet is not statistically significant. This is also true for other data in Tables 3 through 6 (and in a few cases, differences that appear quite small are significant). This is because, given the nature of the data, paired t tests were used to assess the average change in tasks and skills before and after the changeover (i.e., before-after differences were calculated for each individual and then averaged across all cases). As discussed in the text, our data are retrospective. The same sample members reported on their tasks and skills both before and after the changeover. (Ideally, aggregate changes would be measured with longitudinal data from two different—and larger—samples.) While the statistically significant findings clearly indicate the presence of effects, lack of statistical significance does not necessarily imply the absence of effects, only that with these data, no firm conclusions can be drawn.

REFERENCES

Ayres, R., & Miller, S. (1982). Industrial robots on the line. *Technology Review, 85*(4), 35-46.

Bell, D. (1973). *The coming of post-industrial society.* New York: Basic Books.

Blauner, R. (1964). *Alienation and freedom: The factory worker and his industry.* Chicago: University of Chicago Press.

Braverman, H. (1974). *Labor and monopoly capital: The degradation of work in the twentieth century*. New York: Monthly Review Press.

Bright, J. R. (1958). *Automation and management*. Cambridge, MA: Harvard University Graduate School of Business Administration.

Chen, K., Eisley, J. G., Liker, J. K., Rothman, J., & Thomas, R. J. (1984). *Human resource development and new technology in the automobile industry: A case study of Ford Motor Company's Dearborn engine plant* (Report No. UM-UTEP-84-7). Ann Arbor: University of Michigan Doctoral Program in Urban, Technological, and Environmental Planning.

Form, W., Kaufman, R. L., Parcel, T. L., & Wallace, M. (1988). The impact of technology on work organization and work outcomes: A conceptual framework and research agenda. In G. Farkas & P. England (Eds.), *Industries, firms and jobs: Sociological and economic approaches* (pp. 303-328). New York: Plenum.

Gabriele, M. C. (1987). GM's top automated plant hits full GM25 output. *Metalworking News, 18*, 10-11.

Greenbaum, J. (1979). *In the name of efficiency: Management theory and shop-floor practice in data-processing work*. Philadelphia: Temple University Press.

Hirshhorn, L. (1984). *Beyond mechanization: Work and technology in a post-industrial age*. Cambridge: MIT Press.

Hunt, H. A., & Hunt, T. L. (1983). *Human resource implications of robotics*. Kalamazoo, MI: Upjohn Institute for Employment Research.

Katz, H. C. (1985). *Shifting gears: Changing labor relations in the U.S. automobile industry*. Cambridge: MIT Press.

Katz, H. C., & Sabel, C. F. (1985). Industrial relations and industrial adjustment in the car industry. *Industrial Relations, 24*, 295-315.

Milkman, R., & Pullman, C. (1988). *Technological change in an auto assembly plant: A case study of GM-Linden* (Mimeo). New York: Labor Institute.

Miller, S. M., & Bereiter, S. R. (1985). *Modernizing to computer-integrated production technologies in a vehicle assembly plant: Lessons for analysts and managers of technological change*. Paper presented at the National Bureau of Economic Research Conference on Productivity Growth in the U.S. and Japan, Cambridge, MA.

Noble, D. F. (1984). *Forces of production: A social history of industrial automation*. New York: Alfred A. Knopf.

Piore, M. J., & Sabel, C. F. (1984). *The second industrial divide: Possibilities for prosperity*. New York: Basic Books.

Pullman, C., & Szymanski, S. (1986). *The impact of office technology on clerical workers' skills in the banking, insurance and legal industries in New York City: Implications for training* (Mimeo). New York: Labor Institute.

Shaiken, H. (1984). *Work transformed: Automation and labor in the computer age*. New York: Holt, Rinehart & Winston.

Shaiken, H., Kuhn, S., & Herzenberg, S. (1984). The effects of programmable automation on the work environment: A case study of an auto assembly plant. In U.S. Congressional Office of Technology Assessment, *Computerized manufacturing automation: Employment, education and the workplace* (Vol. 2, pp. 293-357). Washington, DC: Office of Technology Assessment.

Spenner, K. I. (1983). Deciphering Prometheus: Temporal change in the skill level of work. *American Sociological Review, 48*, 824-837.

Spenner, K. I. (1985). The upgrading and downgrading of occupations: Issues, evidence, and implications for education. *Review of Educational Research, 55*, 122-154.

Spenner, K. I. (1988). Technological change, skill requirements and education: The case for uncertainty. In R. M. Cyert and D. C. Mowery (Eds.), *The impact of technological change on employment and economic growth* (pp. 131-184). Cambridge, MA: Ballinger.

Tolliday, S., & Zeitlin, J. (Eds.). (1986). *The automobile industry and its workers: Between Fordism and flexibility*. Cambridge: Polity Press.

U.S. Bureau of Labor Statistics. (various years). *Employment and earnings*. Washington, DC: U.S. Government Printing Office.

Wood, S. (Ed.). (1982). *The degradation of work? Skill, deskilling and the labour process*. London: Hutchinson.

Zuboff, S. (1988). *In the age of the smart machine: The future of work and power*. New York: Basic Books.