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ABSTRACT

A pilot research study examined the perspectives of workers in the machining, automotive repair, and printing and graphic arts industries on skill usage and the effects of technological change in the workplace. Research was conducted using site visits, job-shadowing, and in-depth interviews to develop the survey instrument, which was completed by about 700 self-selected workers. Using extensive quotations from the workers surveyed to draw profiles of people in each of the industries, the study determined that workers use a wide variety of manual and mental skills on the job and that these requirements are changing all the time. The change in skill level is determined by how the firm is organized to accommodate the new technology; however, most firms are not integrating education and training into their workplace in a way that effectively incorporates the changing technology and the workers' desires to increase their skills. Few workers over 40 years old in machining and printing were using computerized equipment; firms tended to encourage only their younger workers to pursue skills upgrading. The study concluded that school curricula and training programs must be revised to reflect the new realities in the workplace. (Five appendixes include the study's methodology; questions and responses of all surveyed; and all printers, machinists, and automobile repair technicians surveyed. Fifteen references are included.) (KC)

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University of California, Berkeley

A WORKERS' PERSPECTIVE

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SKILLS, TRAINING, AND EDUCATION IN THE AUTOMOTIVE REPAIR, PRINTING, AND METALWORKING TRADES

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INTRODUCTION AND MAJOR FINDINGS

In 1991-1992, with support from the National Center for Research in Vocational Education (NCRVE), the Machine Action Project (MAP) surveyed seven-hundred thirty workers in three trades: automotive repair, printing, and machining (see Appendix A for information on methodology). The research shows that the increasing use of advanced technologies is effecting these trades. Workers are cognizant of the ways in which these changes have occurred and how they have altered many of the skill requirements of the workers' jobs. Contrary to popular myth, the workers surveyed were generally educated, skilled, and desired advanced training.

- 43.8% have taken at least one skills upgrading course since getting into the trade
- 65.7% would like more variety in their job assignments
- 70.2% use math skills frequently or all the time
- 73.5% use problem-solving skills either frequently or all the time
- 92.2% would like to further advance their skills

There is widespread evidence that the United States lags behind other industrialized countries in several educational and skill areas (Buitelaar, 1988; Hilton, 1991; Murray, 1987). But if ninety-two percent of surveyed workers want to advance their skills, faulting them for the sluggishness of the United States' industries fails to target the underlying cause of the nation's competitive disadvantage. When employers and communities make training available, workers respond. The rapidly widening gap between the skills required by new workplace technologies and the opportunities provided to workers to learn these skills is the symptom, not the cause, of the country's declining industrial competitiveness. Educational and skill deficiencies are the results of a lack of employer planning, a lack of a national prioritization of industry, and weaknesses in the nation's education and training systems.

Vocational-technical training institutions are the first step in advancing the workers' skills in the United States. The increase in technological and skill needs calls for more and changing types of education and training. Educational spending cuts and the lack of a national priority in vocational education has made it difficult for schools to acquire advanced equipment and to design new curriculums necessary to train workers effectively in new manufacturing techniques. These difficulties have led to a system that cannot compete with its foreign counterparts.

The educational system alone cannot shoulder the responsibility for the "skills gap" that currently exists. Research done by MAP, as well as others, has found that in general, companies, especially those with less than two hundred workers, do not put the time and money into the continued education of their workforce (Cann, McGraw, & Forrant, 1991; Kelley, 1988). They may do some cursory level training, especially when introducing new workers to the job, but they are missing a more in-depth commitment to training. MAP's research has found that this missing commitment can manifest in the workplace in many ways; for instance, commonly a firm does some training of workers in an aspect of their field, and then, upon training completion, fails to allow the employee to integrate any of the new knowledge into their jobs, thereby essentially wasting the time and money spent by both the workers and the firm.

Instead of understanding the relationship between having a first class workforce and being first class in the global marketplace, companies refrain from spending the necessary money on their workforce, trying to improve their capabilities through capital investments alone. Some companies set their skill needs on par with the available labor supply rather than investing in training and upgrading their current employees' skills (Rogers & Streeck, 1991).

Firms also use tough economic circumstances to artificially raise skill requirements. This gives them a highly skilled, cheap labor force at no training cost to themselves. An example of using the economy this way took place when a firm in Springfield, Massachusetts advertised a number of new machining jobs in late 1991. As in the past, the company was willing to train new workers. But unlike the past, there were fourteen times as many applicants as there were jobs. The firm put prospective employees through a battery of exams, finally hiring a majority of college graduates, some with advanced degrees. Was this the skill level required for the job? Or was this a result of the available labor market? It is assumed that the global market determines the level of skill needed for a job, but it is also this combination of local forces and economic conditions that can determine the needed skills (Darrah, 1991).

Yet this is not to meant to imply that the need for high-level skills in industry is contrived, especially in the fields investigated by the MAP survey. All three industries do a variety of work, using computer controlled and conventional machines, requiring that workers be trained in several areas. In metalworking, for instance, a study of Western Massachusetts metalworking firms (Forrant & Roditi, 1987) showed that small shops typically produced parts in batch sizes of under a hundred. This variable type of work requires "a high degree of flexibility in its workforce. Extremely short runs make it virtually impossible for a shop doing prototype machining to keep a worker on a single machine day in and day out" (p. 1). Such firms need workers who can do a variety of different jobs, rather than just one, and who have strong basic skills (reading, interpretation of charts and diagrams, math, communication, and problem solving) and computer skills (using Cartesian coordinates, computer programming, data entry, typing, and digital electronics).

THE WORKERS

The following are composites of workers from each of the surveyed trades. They are a result of information obtained in interviews and a statistical analysis of the survey results (for response frequencies, see Appendices B, C, D, and E).

Auto Repair

Upon entering the auto repair trade, thirty-three year old "George Wheels" was relatively prepared in both math and reading skills for the job, but found himself somewhat less prepared for the interpretation of diagrams and manuals that his job required: "Machines only tell you half the story. You have to be able to transfer that knowledge into practical application."

Since George has worked at an automobile dealership for almost seven years, he has taken a class or two to upgrade his skills and to learn about the new electronics in cars today: "Dealers tend to rebuild parts more than shops [that] just put on new ones." In his day-to-day work, he frequently uses his math skills to calculate such things as dimensions and tolerances. He constantly uses his problem-solving abilities to pinpoint problems and find solutions in the cars he fixes. George usually sets up his own machines, and he often has to read and interpret diagrams and charts in the process of working on vehicles. Every day he refers to a variety of manuals and uses such skills as the ability to read and interpret gauges. Although he works on his own, he will ask coworkers for help in solving a problem with some regularity. A little less often he will actually go to his supervisor for help.

Computers are becoming more and more a part of George's job: "None of us were typists, but now we are. You really need to know how to type." He uses computer diagnostics on cars with a great deal of frequency: "We now do diagnostics on complicated machines that we used to be able to do in our heads." He uses computer controlled machinery and data entry less often. Once in awhile he will do some computer set-up and very rarely he might do some actual programming.

George has watched many changes occur in the auto repair business. The pressure has increased significantly since he started thirteen years ago: "The insurance companies' money control is killing the auto repair trade. We need a higher rate to upgrade our equipment. The manufacturer is also cutting back warranty repair time allotments. There is too much pressure and cars are getting harder," he says. "Sometimes I don't even have time to do a quality check on my work!"

Consequently, George believes that requirements for mechanics ten years from now will be much higher, as inspection standards increase and cars become even more complex. "You can never go to school enough, as fast as this stuff changes . . . the parts replacement guy is history!" Future workers will have to rely on math and reading much more often than now, and will have far more diagrams, manuals, and charts to read and interpret. Computers will be an everyday experience for most. George is encouraged to take skills upgrading classes by his employer, and finds he uses those skills on the job. He actively seeks to advance his skills, as increasing technology is the biggest change he has seen in the trade during the past five years: "Education is the key; you can't be in this field without it."

George likes the autonomy in his work and wants to stay in the trade. Usually he gets to decide his own sequence of tasks, and the power to make his own decisions is personally rewarding. He has invested both time and money in his trade: "I've got thousands of dollars worth of tools, and people assume the company bought them." But he finds the lack of respect that he gets from people disturbing: "With all of the technology we have to know and use, people don't give us enough understanding. Cars are very complicated today. We're not just grease monkeys or mechanics. We're technicians, and should be paid and treated as such."

Printing and Graphic Arts

"Karen Ink" is a thirty-four year old woman in Dallas, Texas. She entered the trade through a vocational-technical high school, where she studied printing and a bit of graphics: "You don't really need a college degree. You need common sense. "She felt that high school prepared her in terms of reading and math, but didn't really give her enough job specific skills."

Karen has worked at a small print shop for about eight years. In her job she finds that she uses math all the time, especially measuring skills. They are essential for doing even simple tasks, such as determining the proportions for changing the size of an item in a layout. She is responsible for solving whatever problems may come up on her printing jobs, and must watch for and anticipate problems. This may mean keeping an eye on the way the press is operating, or making sure that a run is registering properly and fixing it if it is not. Usually she does not interpret many diagrams or charts, though she will read a manual once in a while and frequently finds herself checking the gauges on the press. She sets up her own presses, most of which are not yet computerized and she determines the sequence of tasks, though much of it is actually predicated by the job itself. Each job gives her a great deal of discretion in the way that it is done. Quality control is essential for every job, and she must constantly inspect her work. Overall, she has a great deal of control over her own work.

Karen finds that typesetting today is much different than when she began in the trade, thanks to computers. Desktop publishing has transformed the nature of the work that she does, as well as having increased the possible standards of precision. More work actually comes in camera-ready, as customers do their own paste-up and typesetting on their computers, cutting out the need for Karen to do any of it. This also increases the level of precision in the industry because a computer can be infinitely more precise in the way that it positions a letter than can someone doing paste-up with a waxer. Customers are used to seeing the precision of the computerized work, and demand it for all of their printing needs. Traditional typesetting is no longer practiced except in specialty shops. Other changes have included a growing awareness of the toxicity of the inks and solvents in use, and a drive toward using more recyclable materials.

She sees a steady increase in the level of skills that will be necessary in the future. Math and reading may be more important, but clearly computer knowledge will be a must. She also sees the advent of new machines in the shop: "I think the perfecting unit is the new future of printing. It prints on both sides." The changes taking place in the industry demand that the workers keep updating their skills.

Karen has seen more women enter the field since the advent of computers. As she puts it, "Printing is easier for women to get into now because of the computers. You can learn a lot of the trade before you get into the shop. The old way of typesetting was learned only in the shop so it was mostly white men."

She would like to advance her skills, but the shop she works at does not really encourage workers to take courses to upgrade their skills. When she has acquired new skills though, she finds that she can use them on the job. In fact, she finds that she is actually able to acquire new skills on the job. She is confident that she would like to stay in the trade.

Machining

"Steve Metal" is a thirty-five year old machinist in St. Louis, Missouri. He works at a shop that employs a total of thirty-seven people. He has worked in the trade for eleven years, and got into it through courses at a trade school. The first thing he has to say about his job is that he is very concerned about the industry: "I work on great machines and have great skills, but there is no work to put on them." He has worked at a variety of different shops in his career, starting at a large unionized firm. He was laid off several years ago, and has since found work at smaller shops. But, he consistently has the least seniority and is prime for the next layoff. He complains that the lack of industry stability has severely affected his income level.

Although his current shop is not great about encouraging workers to get training, he has thought seriously about taking more classes: "I want to keep learning; there is a lot to learn in the trade." Steve has to be on his toes at work. He finds he needs more skills than his job description covers, and definitely more skills than were needed at his first large plant job: "You get into a shop and you have to use blueprints made by engineers who are pushed too hard and leave things off. You have to know and catch that!"

Steve does not read manuals often, but he reads gauges, does set-ups, and uses blueprints on a daily basis. Other skills he uses constantly are math and problem solving. He determines the order of the work that he does, including selecting the appropriate tooling. He inspects his own work constantly, and picks up any problems that occur and fixes them. He even repairs his own machine when needed. His job responsibilities require numerous, diverse skills.

Computers have made their inroads into his trade. Though he never does computer diagnostics and rarely does computer programming, it is quite common for him to run a Computer Numerically Controlled (CNC) machine, and to do data entry. Once in awhile, he might make changes in a program.

In the future, Steve sees a strong need for more computer skills, especially since he observes that "the companies are building the skills into the machines, and they are making big strides toward deskilling." Math and reading skills will also be very important: "Lots of skills for specific machines can be learned on the job. Kids need to learn the theory and logic parts the most. The schools need to rely on the workplace more. We need a flexible enough education system to accommodate changes."

THE SKILLS

Skill is an elusive concept to define and measure. Skill levels are usually determined by the amount of formal training a person has and/or the time spent doing a particular job. Until quite recently, the ability of a worker to perform narrowly defined tasks by rote was a key measure used by most U.S. manufacturing facilities to analyze the skills of their workforce. A worker who could quickly machine the same hole in an engine block repeatedly, every eight hour shift was a prized employee. The hole would eventually be inspected by at least one other worker. If it was not done to specifications, it would most likely be handled by several other workers and managers as they tried to determine what to do with the part. The worker, highly qualified to drill the hole, could do little else if such work was no longer available in the facility. This conventional approach to skill and work organization is no longer appropriate.

The ability to set up and operate several machines and continually insure the quality of the work or service provided is now the norm in world class businesses. To achieve such a standard in the United States, broad-based training is needed. It is no longer enough to be able to successfully complete a variety of disconnected job assignments. Workers now need to know why they are doing what they are doing. And they need to be able to learn how to utilize new technologies and adapt to changing job requirements quickly (Forrant & Roditi, 1987).

Observable skills such as drilling a hole or tightening a nut are only a portion of what it takes to work effectively in rapidly evolving trades (Darrah, 1991). Workers who operate and set up several machines are using math and reading skills more frequently. Auto mechanics need to use manuals, computer diagrams, and problem-solving skills to track down a faulty electronic part in a car engine. Workers need to draw on the skills of other employees by asking questions of each other to complete job assignments efficiently.

A worker's ability to solve problems, or even the number of times in a day that she is called upon to solve them, is not easily measured by simple observation. It comes from the worker knowing who to turn to when she does not have an answer, what to keep an eye on to make sure that everything is operating smoothly, and when to make adjustments in what she is doing. This is true whether she is tightening a nut, watching the ink level of a press, or creating a precision part with a CNC. The mental labor required of workers in the three industries studied is taking the place of much of the brute strength and manual work required in the past.

Basic Skills

The composites of "George Wheels," "Karen Ink," and "Steve Metal" amplify just how important basic skills such as math, reading, and problem solving are for workers.

Only ten percent of all workers surveyed indicated that they rarely or never use math. The number who rarely or never use reading skills is thirty-seven percent for printing and graphic arts, and forty-five percent for machining, but this still indicates that a majority of these workers realize that reading is essential for the successful completion of job assignments. The ability to break down the component parts of a job and figure out how to get it done, the problem-solving capacity, is extremely important. As many as eighty-six percent, sixty-eight percent, and seventy percent respectively of auto, printing, and machining workers draw upon this ability all the time or frequently (see Table 1). Many workers interviewed indicated that the use of these skills is so integral to the successful completion of their jobs that they did not understand why the question was being asked.

Percentage of Workers Using Basic Skills (Table 1)*

		All the Time or Frequently	Occasionally	Rarely or Never
Auto Repair				
	Math	55.0	34.4	10.6
	Reading Manuals	75.5	18.6	5.9
	Reading Gauges	79.7	14.4	5.8
	Interpreting	57.0	25.0	18.1
	Problem Solving	86.1	8.6	5.4
Printing				
	Math	76.4	14.3	9.3
	Reading Manuals	25.3	37.7	37.0
	Reading Gauges	37.8	27.2	35.0
	Interpreting**	25.4	27.7	46.9
	Problem Solving	67.8	16.7	15.5
Machining				
	Math	75.0	14.5	10.6
	Reading Manuals	28.6	36.3	45.2
	Reading Gauges	65.6	18.1	16.3
	Interpreting	62.1	16.7	21.1
	Problem Solving	70.2	17.8	12.0

* totals may not equal 100% due to rounding error
** Interpreting diagrams, blueprints, manuals, and tables

Another key element is the ability to discuss work-related problems and to be able to ask the right questions to help understand how to set up a machine, repair a broken part, or diagnose a malfunctioning system (see Table 2). Several workers indicated that communication between coworkers and supervisors is becoming even more frequent and essential as workplace changes occur. They said that communication is key to understanding and incorporating the changes in the work structure, from an individualized organization to a new type of group work. "Things are changing a lot. They combined one hundred and seventy-five job titles into four, and have us working in teams now," said one machinist. As their job descriptions broaden and they learn more of their coworkers' skills, the workers combine efforts to tackle new problems and aspects of the job. In these instances, communication becomes one of the most important points for success.

Percentage of Workers Who Ask for Help in Solving Problems (Table 2)*

		All the Time or Frequently	Occasionally	Rarely or Never
Auto Repair				
	Ask coworkers	35.1	44.9	20.0
	Ask supervisor	24.6	38.3	37.1
Printing				
	Ask coworkers	29.5	47.6	22.9
	Ask supervisor	20.8	44.3	34.9
Machining				
	Ask coworkers	21.2	33.3	45.5
	Ask supervisor	16.0	43.5	40.5
All Workers				
	Ask coworkers	27.8	46.1	26.1
	Ask supervisor	19.9	2.5	37.6

* totals may not equal 100% due to rounding error

Workers indicated slightly less communication with their supervisors than with fellow employees. Overall, just under thirty-eight percent rarely or never asked their supervisors for help. It is interesting to note that workers also stated that poor communication was one of the most problematic parts of their jobs. "The management asked us about the type of control to buy for a retrofitting machine. It was a heated discussion. Management didn't listen, and now they regret it," said one worker. Another recounted that, "One of the most frustrating things about the trade is that management won't listen to you about what needs to be done. Most of management are college graduates, and they won't give anyone else credit for having knowledge. If they would listen, it would save many hours and headaches." This confirms data from a machine shop survey which found that it is now a top priority to educate supervisors about worker involvement and participation in shop floor decision making (Cann et al., 1991).

Computer Skills

Computers are key to the changing skills requirements of workers. Auto repair workers utilize computers more than their counterparts in printing and machining, with forty-one percent using them regularly to perform diagnostic tests on automobiles. Close to twenty percent of the workers perform data entry. As many as twenty-three percent of auto repair, fifteen percent of printing, and eighteen percent of machining workers use computer controlled machinery always or frequently. Clearly the evidence of the growing influence of computerization is found in these job requirements (see Table 3).

Percentage of Workers Using Computer Skills (Table 3)*

		All the Time or Frequently	Occasionally	Rarely or Never
Auto Repair				
	Data entry	21.6	20.5	58.3
	Operate CNC	22.6	14.0	63.4
	Computer set-up	11.5	13.7	75.0
	Computer diagnostic	41.3	17.8	40.5
	Computer programming	8.0	5.4	86.5
Printing				
	Data entry	16.7	7.3	76.0
	Operate CNC	14.6	9.1	76.3
	Computer set-up	15.1	5.8	79.1
	Computer diagnostic	2.3	5.5	92.2
	Computer programming	2.7	4.3	93.0
Machining				
	Data entry	16.2	9.2	74.0
	Operate CNC	17.6	9.5	72.9
	Computer set-up	6.6	3.4	90.0
	Computer diagnostic	2.2	4.2	93.6
	Computer programming	4.8	5.5	89.7

* totals may not equal 100% due to rounding error

Increased computer usage on the job is causing two contradictory things to occur regarding job content. Workers who regularly utilize computers are receiving an increase in training and are learning new skills, or being "up-skilled." At the same time, those individuals performing job functions eliminated by technology are seeing the skill requirements of their jobs lessened or "down-skilled." In the machine shop, for example, the worker trained to perform complicated machine set-ups with the aid of a computer is replacing the traditional set-up specialists who now see many of the skills he took years to learn contained in software programs. Set-ups that were done manually and took hours to perform can now often be done in minutes using this technology.

When a print shop gets a computerized press and trains an employee to program and run it, it increases that worker's skill. Conversely, if "Karen Ink" had regularly done press set-ups, but was not trained to run the new computer equipment and assigned instead to run-quick copy machines, she would have been deskilled. When an auto shop teaches "George Wheels" to work on electronic fuel injection systems it is up-skilling. However, if he is not taught these systems, and due to his lack of training he gets shifted to do quick oil changes, he is being deskilled. In each of these examples, new skills are introduced into the workplace, and consequently either up-skill or deskill the workforce. Their application is what determines the result. Unless the new skills are broadly taught, the cumulative effect upon the workforce is that the majority are left behind as the new technology causes job content to change.

Traditionally, workers with the most seniority attain the highest skill levels in a firm and perform a good deal of the most complicated work. With the introduction of computers, this is changing. Computerized equipment requires some skills related to traditional equipment, but also includes many new ones. One major difference is that the subtle knowledge of the peculiarities of certain metals and tools, inks and papers, and parts and the idiosyncratic behavior of the machines, once the worker's highly skilled private knowledge attained through years of experience, now becomes public knowledge, owned by the company and stored in the computer's memory. The irony here is that, quite often, programming presupposes a knowledge which in many cases is only acquired through shop floor experience and therefore resides with the more experienced workers (Jones, 1982). This is a situation that must be resolved in order to have the technologies utilized successfully. Also, a shop's traditional staff needs to have extensive training to upgrade their skills or the new skill requirements will quickly pass by them.

Ideally, workers and managers receive the training necessary to maximize the use of new technologies when the ideas are introduced into the work environment. Yet, a machine shop survey (Cann et al., 1991) indicated that many have high-tech equipment that is severely underutilized. For example, of those shops with CNC machines, only sixty percent fully utilized them. Of those with Computer Assisted Design (CAD), only forty percent fully utilized that capacity. In addition, many shops have equipment that is capable of performing much higher volumes of work than they do. Some of this under-utilization is the result of a lack of work, but some is not. As a student in a CNC class, sponsored by MAP, mentioned, "I am learning how to run a machine that has been sitting idle. The company only paid to have one person trained to run it when it was bought. But then he transferred out of the department, and no one else can run it." In addition, although workers were not asked what types of machines they repaired, empirical evidence suggests that, in the majority of cases, traditional machines were the only type. This is another example of the two sided effect of technology on workers and job content. It is deskilling the traditional user/repairer of the machine while creating a new category of skilled worker who specializes in the repair of high tech equipment. More research needs to be done on this issue as well as on the utilization of auto repair and printing technology.

Changing Work

Increasing technology worldwide has affected which workers perform which tasks. A study done by Kern and Schumann (1989) points to German firms as role models for adapting to these changes. The Germans have shifted their education and training focus to redesigning job responsibilities. Workers are entering employment with greater skills than ever before as a consequence of improved technical high school and apprenticeship programs. This breadth of worker skill creates the opportunity for firms to restructure, combine several isolated tasks into new job categories, and utilize worker skills more completely. It also coincides with efforts over the last several years to reorganize firms to make them more responsive to market and customer demands. Flexible firms require highly skilled workers—workers able to learn new things and integrate them into their daily routine.

The German study found that workers had a broad-skill base. They do their own set-ups, as well as production and maintenance work. This allows the employer to utilize costly machinery to the maximum. Maintenance workers are also responsible for production; there are now maintenance mechanics, maintenance-electricians, and electronic specialists. The boundary between mechanics and electrician/electronic specialists has blurred. When compared to the surveyed firms in the MAP study, German companies are doing a more effective job of maximizing the potential for state-of-the-art production.

Rather than broadly train workers in the use of a variety of computer technologies, survey results indicate that U.S. firms may be segmenting the work and the workers. In a 1991 survey of machine shop owners and managers, only 17.6% of respondents said that they relied on their machine operators to perform programming operations. To illustrate, consider a company with a number of computerized machines. They may decide that is more cost effective, in the short run at least, for them to hire a single person to do the programming for all of the computerized machines. On the other hand, a similar strategy for a firm with only one computerized machine would leave the employee idle much of the time. Instead, they must rely on someone within the firm who can do other things while not programming, or else subcontract the programming tasks (Cann et al., 1991). Segmenting keeps workers and firms from obtaining their fullest potential.

Changing Workers

The decision as to who programs the machines significantly affects the control structure of the work inside a firm. The findings of Harley Shaiken (1984) tend to support the argument that many new technologies are in fact, if not in specific intent, deskilling large groups of blue collar workers. Highly skilled work is shifted to engineers, managers, and outside personnel, removing a measure of power from the shop floor. Our research determined that while most workers were not getting the chance to do the computer programming and set-up, of those that were, 83.3% continued to do traditional set-ups with the same frequency. Few people, only 3.1%, set up computerized machinery exclusively. (This pattern may be affected by firm size—most of the firms used in this survey were small with under a hundred workers. A large firm which has kept up with technology will have more computerized machines and be more likely to have employees working exclusively on them.) The research also indicates that because workers are doing both types of set-up, they are not learning the high-tech skills at the expense of traditional methods. *But this does not mean that all workers who do traditional set-ups do* *computerized set-up*. In fact, eighty-one percent of those who always or frequently do traditional set-ups, rarely or never do computerized ones. This pattern may be affected by the fact that most of the firms used in this survey were relatively small (under a hundred production workers). A large firm that has kept up with technology will have more computerized machines and be more likely to have employees working exclusively on them.

The survey data also suggests definable trends between the use of technology and a worker's age. Younger workers use technology more often than older workers. An increase in worker age is often accompanied by a decrease in technology (and, therefore, machine) usage. Machinists in their twenties were the most likely to use computer controlled machinery (28.1% of them used it all the time or frequently compared to 18.3% of those in their thirties, 14.3% of those in their forties, and 0% of those older). In printing, the use pattern is slightly different (15.6% of those in their twenties, 18.3% of those in their thirties, 10.5% of those in their forties, and 0% of those older), but it still supports the argument that older workers are not being taught to use new technology. These same trends are found when examining the more in-depth technological skills such as computer set-up, computer diagnostics, and computer programming.

Only in auto repair was age found not to be a significant predictor of who was trained on and utilized new technology. Through anecdotal evidence, it became clear that the biggest factor was whether a worker was at a dealership or at an independent shop. The auto repair industry differs from the printing and machining industries in that it has an extensive, industry-led training system based almost exclusively at car dealerships. Each model and/or engine change, and the introduction of numerous onboard computer systems regulating virtually every aspect of a car's inner workings, requires that car makers keep dealership employees up to date so that they can service vehicles. Workers at independent garages generally do not have this available to them. In fact, when MAP ran skills upgrading training on Ford and General Motors cars, workers from small, independent garages were the most eager to attend.

Age seemed to have a great deal to do with the way other survey questions were answered, but further research needs to be done on this issue. There was a strong indication that younger workers feel more encouraged by their employers to take skills upgrading courses and to operate computerized equipment. In addition, of the workers that have taken skills upgrading courses, younger workers find they are more able to use the skills they acquired than are older workers. This is despite the fact that workers in their forties were actually the most educated in their trades (80.0% of printers in their forties, along with 57.1% of auto workers and 34.5% of machinists of the same age had at least some college education). Younger workers are more likely to believe that they can acquire new skills on the job.

Similarly, younger workers have been exposed to computer technologies that were non-existent when older workers were in school. This helps to explain why it appears that companies provide younger workers with more of a chance to learn new technologies on the job. Because they are more familiar with computer technologies, they get more training. Older workers give specific examples of this trend. One person stated "I asked to learn how to run the wire EDM (Electrical Discharge Machinery), but they told me I was too old." Another older worker said, "I wanted to learn CNC, but the company decided I was more valuable teaching kids who knew CNC how to run manual machines." Age was a disadvantage for the first worker, causing him to have fewer opportunities at work. Yet for the second worker it is not so clear. He was given some advancement precisely because of his age and knowledge, and asked to run a training program with the skills that he did have. However, to the forty-year old worker with twenty-five years left before retirement, not getting the chance for training on new technologies significantly decreases job security and opportunities for personal advancement.

THE LEARNING ENVIRONMENT

While attitudes are beginning to change, workforce education and skills training are often viewed with a prejudiced eye in the United States. Parents caution their children to do well in school so they will not have to earn a living in what have been historically labeled "blue collar" occupations. That the computer revolution has impacted every aspect of the three trades examined in this survey is never considered. The increasingly high levels of math and problem-solving skills required to operate sophisticated printing presses, automotive diagnostic equipment and computer driven machine tools have not changed the mistaken perception of the trades as simply greasy, nonintellectual jobs. Youth are not encouraged to enter these trades, and they are portrayed as jobs without a future. Yet the manufacturing trades include some of the fastest changing fields today.

This mistaken perception has affected postsecondary education as well. Once a worker enters a trade, continuous education and training programs are usually not available in any organized or systematic way. For example, a study done by Maryellen Kelley and Harvey Brooks (1988) found that only one quarter of all metalworking plants in the United States provide any training at all. "There is a pronounced tendency to view basic skills deficiencies as personal failures, to blame individual workers for a lack of will and determination to overcome their weaknesses. The image of the ignorant and illiterate blue-collar worker has been enshrined in American culture" (Marschall, 1990, p. 13).

Most of the workers surveyed indicated that by the year 2000 reading, math, problem-solving, and computer skills will be even more integral to their trades than they are today. To accommodate this increasingly complex future, workers are taking skills upgrading classes. Over forty-three percent of the workers surveyed have taken at least one skill upgrading course since getting into the trade. Many, especially auto repair workers at dealerships, have taken more. Over sixty-five percent of all auto mechanics have taken at least one course, and many have taken three or four. Also, more than ninety-two percent of those surveyed said that they would like to advance their skills, and just under sixty-seven percent wanted more variety in their jobs. However, anecdotal information suggests that workers are frustrated with their inability to integrate their upgraded skills into their jobs. They find that they are not being rewarded for their increased skills and their increased value to the company. Clearly then, this is not a case where workers are simply unwilling and/or unable to learn new skills.

Workers are aware of the problems that exist as a consequence of the changing levels in technology. Increasing technology introduces new skill demands into the workplace. It brings additional expenses such as new equipment and repair. It changes social relations by necessitating a new work organization. These transitions can be made smoothly and inclusively with the workforce, or, if made in a way that does not distribute opportunity equally, may put unrealistic expectations or demands on the workforce, and leave the new technology underutilized.

Many of the problems firms face in the education and training arena have their origins in decisions made by business owners close to eighty-five years ago. The routinization of work—the process of breaking down every job to its basic elements and training a worker to just perform a simple function—still prevalent in much of America's industry and service occupations, was abandoned by many Western European and Japanese companies several years ago (see Dertouzos, 1989; Wood, 1989). Forced to play catch-up, U.S. employers are beginning to see the light. William Wiggenhorn, Motorola's Corporate Vice-President for training, recently stated:

> Ten years ago we hired people to perform tasks and didn't ask them to do a lot of thinking. If a machine broke, workers raised their hand, and a troubleshooter came to fix it. . . . Then all the rules of manufacturing changed, and in our drive to change with them, we found we had to rewrite the rules of corporate training and education. We learned that line workers had to actually understand their work and their equipment, that senior management had to exemplify and reinforce new methods and skills if they were going to stick, that change had to be continuous and participative, and that education—not just instruction—was the only way to make all this occur. (Wiggenhorn, 1990, p. 71)

Three approaches for dealing with the future are conceivable. Firms can avoid the issue of education and training altogether, looking outside the company when new skills are needed. They can focus on providing training on a case by case basis, usually when a new machine is introduced, without an overall strategic plan. Third, companies can put a comprehensive education and training program together that offers every employee an opportunity to improve him or herself. This final approach will increase the capacity of the entire firm to work smarter, not just individual workers.

THE IMPLICATIONS

The MAP survey results indicate that attention needs to be focused on more than just the issue of hands-on skills training because it is far too limiting. Workers indicate that mathematics, reading, and problem solving are as important, if not more so, than merely acquiring the ability to set up a specific machine or troubleshoot an electronic device inside a late model automobile. Technological advances have changed and will continue to alter entry level and long-term career skills requirements in most occupations. Workers must be able to use technical manuals which explain how complex systems work, and then find the correct diagnostic tests to apply in order to quickly and correctly perform manufacturing processes or make repairs. Particularly in the area of set up and repair, workers must be able to analyze information and construct a plan of action. Hands-on training is just not enough.

Despite the changing knowledge required, the approach we use to pass on knowledge to workers has actually changed very little. This is problematic as the rapidity of technical change makes it mandatory that workers "learn how to learn" and that firms discover ways to integrate newly learned skills quickly into the way they organize their shop floor. Schools and training centers must establish programs that concretely demonstrate to students how math and reading skills are related to successful job performance. Employers and workers need to visit classrooms and describe to students how they use math and reading on the job. Time should be spent with students in classrooms working on hands-on problem-solving projects.

The traditional way of teaching, which emphasizes individual learning and projects, needs to be overhauled. Workers in firms changing to participatory work cells indicated that to be prepared for the workplace, students must work on group projects which require them to plan a job from start to finish, including sequencing of tasks, designing quality control measures and figuring cost of the work. This will help develop problem-solving and communications skills.

For apprenticeship training programs and skills upgrading courses to be effective, firms need to think about how to integrate newly learned skills into the work environment. It does little good, for example, to pay for CNC training for employees, there is no plan in place to allow them to use their newly learned skills. But this happens all the time. Interviews with workers in all three industries indicated that when workers see the results of their efforts wasted, they are less inclined to be cooperative about future training. They see it as just another irrelevant demand by management. This is especially true in firms that require workers to attend courses on their own time.

To prevent such a situation from occurring, firms need to develop an educational plan and treat it as an integral part of their overall business plan. Skill levels need to be assessed so that necessary courses can be identified that coincide with any planned technology acquisitions or work reorganization efforts. Evidence from interviews suggests that quite often firms decide that they want to introduce new technology and they spend money planning for the change, only to find out a year into the project that the workforce lacks the math and reading skills needed to implement such a program. Similarly, firms decide to spend money on advanced computer controlled equipment without ever discussing the purchase with their workers (Cann et al., 1991). When the machines arrive, there are few, if any, workers capable of setting up and operating the equipment effectively. An adherence to the piecemeal approach to workforce education will result in nothing more than piecemeal results.

SUMMARY

This project's examination of workers in the auto repair, printing and graphic arts, and machining trades has determined that workers use a wide variety of manual and mental skills on the job, and that these requirements are changing all the time. Increasing technology in these fields can either increase or decrease the skill levels of jobs. The change in skill level is determined by how the firm is organized to accommodate the new technology. It would appear that most workers, while they recognize the impact computers are having on their jobs, are not being taught to take advantage of it. The new technologies are not being adequately utilized.

Age was found to be a key determinant of who uses new technologies. In printing and machining, few workers over the age of forty worked on computerized equipment. Even though almost all workers surveyed were interested in skills upgrading, firms tended to encourage only their younger workers to pursue such education. This results in older workers being further deskilled.

As more and more workplaces are reorganized to include group and team work, problem-solving and communication skills are used regularly. Moreover, the transformation of work, caused by the rapid increase in the use of computerized machinery, makes basic computer literacy an essential tool for worker success. Most firms are not integrating education and training into their workplace in a way that effectively incorporates the changing technology and the workers' desire to increase their skills. Education and training programs must revise their curriculums to reflect these new realities in the workplace.

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APPENDIX A
METHODOLOGY

This project began as a pilot study done by the Machine Action Project (MAP). A Research Task Force was developed, consisting of educators, administrators, and other professionals in technology, industry, and vocational education. The Task Force conducted interviews with supervisors and workers, and assisted in the development, piloting, administration, and interpretation of the pilot study.

The purpose of the research was to examine the workers' perspectives on skill usage and the effects of technological change in the workplace. Machining, automotive repair, and printing/graphic arts were selected for the study because they represent critical employment sectors in the rapidly changing, high-technology industries in Hampden and Hampshire Counties of Massachusetts, where the project was run. The pilot study then served as a springboard for a MAP project which surveyed a larger, more geographically dispersed group of workers.

The methodology for this study was derived from an applied approach to research, utilizing site visits, job-shadowing, and in-depth interviews to develop the survey instrument. The survey was designed for use across the three trades to allow comparisons among, as well as within, the groups, so that implications across the trades could emerge.

The research sample was drawn from shops in the three trades during 1991. Several criteria were used for selection, including size, representativeness of industry and workforce sectors, and willingness of management to authorize participation in the research. Shop size ranged from very small (one employee) to much larger (120 production workers). Several sites were selected for the survey: 51.9% were done with workers in Western Massachusetts (Springfield); 15.9% with workers in Central Massachusetts (Worcester); 23.2% of the workers were in St. Louis, Missouri; and 9.0% were in Dallas, Texas. Of this total pool of respondents, 36.0% were in the printing trade, 38.0% were in the machining trade, and 26.0% were in the auto repair trade. Of the respondents, 6.4% were identified as African American, and 3.7% were identified as Latino. A total of 12.8% were women and 87.2% were men. Five percent of the respondents were interviewed in person.

Respondents were self-selected were asked to remain anonymous. Responses to demographic questions were optional. Surveys were handed out and collected by shop supervisors, therefore control over distribution and subsequent biases was not possible.

APPENDIX B

ALL WORKERS: QUESTIONS AND RESPONSES OF ALL SURVEYED

Preparation for First Job:

	Math %	Math N=	Reading %	Reading N=	Interpreting Diagrams, Manuals, & Blueprints %	Interpreting Diagrams, Manuals, & Blueprints N=
Very Unprepared	3.9%	28	4.8%	33	10.5%	75
Somewhat Unprepared	7.9%	57	3.0%	21	11.6%	83
Unsure	6.1%	44	3.2%	22	14.0%	100
Somewhat Prepared	38.6%	277	28.3%	195	39.1%	279
Well Prepared	43.4%	311	60.7%	419	24.7%	176
Total	100.0%	717	100.0%	690	100.0%	713

How Often Skills Are Used:

	Math %	Math N=	Problem Solving %	Problem Solving N=	Set-Ups %	Set-Ups N=
All the Time	45.3%	327	47.2%	340	39.5%	283
Frequently	24.9%	180	26.3%	189	19.4%	139
Occasionally	19.7%	142	15.0%	108	16.0%	115
Rarely	6.6%	48	6.4%	46	9.5%	68
Not at All	3.5%	25	5.1%	37	15.6%	112
Total	100.0%	722	100.0%	720	100.0%	717

	Interpreting %	Interpreting N=	Reading Manuals %	Reading Manuals N=	Reading Gauges %	Reading Gauges N=
All the Time	29.1%	209	18.2%	131	35.3%	251
Frequently	18.6%	134	21.4%	154	24.1%	171
Occasionally	22.8%	164	32.2%	231	20.4%	145
Rarely	13.1%	94	18.8%	135	10.8%	77
Not at All	16.4%	118	9.3%	67	9.4%	67
Total	100.0%	719	100.0%	718	100.0%	711

	Ask Coworker for Help %	N=	Ask Supervisor for Help %	N=	Computer Data Entry %	N=
All the Time	8.7%	62	4.5%	32	8.5%	61
Frequently	19.1%	137	15.3%	108	9.2%	66
Occasionally	46.1%	330	42.5%	299	11.5%	82
Rarely	20.3%	145	26.7%	188	16.2%	116
Not at All	5.9%	42	10.9%	77	54.5%	390
Total	100.0%	716	100.0%	704	100.0%	715

	Operate Computerized Machinery %	N=	Computer Set-Ups %	N=	Computer Diagnostics %	N=
All the Time	11.2%	80	6.6%	47	5.6%	40
Frequently	6.6%	47	4.3%	31	6.9%	49
Occasionally	10.5%	75	6.9%	49	8.2%	58
Rarely	11.7%	83	12.2%	87	9.9%	70
Not at All	60.0%	427	70.0%	499	69.4%	492
Total	100.0%	712	100.0%	713	100.0%	709

	Computer Programming %	N=
All the Time	29.%	21
Frequently	2.0%	14
Occasionally	5.0%	36
Rarely	11.2%	80
Not at All	78.9%	563
Total	100.0%	714

How Often Will These Skills Be Used in the Year 2000?:

	Math %	N=	Reading %	N=	Interpreting %	N=
Much Less Often	4.1%	29	2.5%	18	2.3%	16
Less Often	11.8%	84	5.2%	37	8.8%	62
No Change	25.1%	179	28.3%	201	30.4%	214
More Often	32.3%	230	34.4%	244	33.4%	235
Much More Often	26.7%	190	29.6%	210	25.0%	176
Total	100.0%	712	100.0%	710	100.0%	703

	Computer Diagnostics %	N=	Computer Data Entry %	N=	Operate Computerized Machinery %	N=
Much Less Often	2.8%	20	2.1%	15	2.3%	16
Less Often	3.1%	22	2.4%	17	2.0%	14
No Change	17.2%	121	12.7%	90	13.6%	96
More Often	33.6%	236	42.5%	302	37.2%	263
Much More Often	43.2%	304	40.4%	287	45.0%	318
Total	100.0%	703	100.0%	711	100.0%	707

	Computer Set-Ups %	N=	Computer Programming %	N=
Much Less Often	4.0%	28	3.8%	27
Less Often	3.4%	24	2.7%	19
No Change	20.7%	146	20.7%	147
More Often	36.0%	254	34.1%	242
Much More Often	36.0%	254	38.7%	275
Total	100.0%	706	100.0%	710

	Technology Changes Will Require Higher Level Reading Skills %	N=	Technology Changes Will Require Higher Level Math Skills %	N=	My Position in the Trade Has Matched My Skill Level %	N=	My Position in the Trade Requires Fewer Skills Than I Have %	N=
Agree	62.7%	448	61.6%	440	36.2%	258	37.3%	263
Unsure	24.5%	175	24.8%	177	30.8%	219	27.1%	191
Disagree	12.7%	91	13.6%	97	33.0%	235	35.6%	251
Total	100.0%	714	100.0%	714	100.0%	712	100.0%	705

	I Would Like to Remain in the Trade %	N=	The Shop Encourages Skill Upgrading %	N=	I Use Skills Acquired in Training %	N=
Strongly Disagree	3.5%	25	5.4%	39	4.4%	31
Disagree	6.3%	45	17.6%	126	10.0%	71
Unsure	25.1%	180	13.4%	96	11.7%	83
Agree	44.6%	320	50.3%	361	60.1%	428
Strongly Agree	20.6%	148	.13.2%	95	13.9%	99
Total	100.0%	718	100.0%	717	100.0	712

	I Can Acquire New Skills on the Job %	N=	I Would Like to Advance My Skills %	N=	I Would Like More Variety in My Job Assignment %	N=
Strongly Disagree	4.7%	34	1.4%	10	3.5%	25
Disagree	7.8%	56	0.4%	3	10.8%	77
Unsure	7.9%	57	6.0%	43	20.0%	143
Agree	63.3%	454	58.9%	422	51.0%	364
Strongly Agree	16.2%	116	33.3%	239	14.7%	105
Total	100.0%	717	100.0%	717	100.0%	714

	Skills From Other Jobs Help Me in This Work %	N=
Strongly Disagree	3.8%	27
Disagree	11.2%	80
Unsure	9.5%	68
Agree	55.4%	396
Strongly Agree	20.1%	144
Total	100.0%	715

Upgrading Courses:

# of Courses	%	N=
One	26.8%	194
Two	9.3%	67
Three	4.3%	31
Four	1.0%	7
Five	0.6%	4
Six	0.6%	4
Seven or More	1.2%	9
None	56.4%	408
Total	100.0%	724

Averages of Selected Questions:

	Total N	=729
Age	34.0	402
Years at Firm	7.48	573
Years in Trade	11.7	591
Starting Salary	$5.23	473
Present Salary	$11.80	426

APPENDIX C

PRINTING: QUESTIONS AND RESPONSES OF ALL PRINTERS SURVEYED

Preparation for First Job:

	Math %	Math N=	Reading %	Reading N=	Interpreting Diagrams, Manuals, & Blueprints %	Interpreting Diagrams, Manuals, & Blueprints N=
Very Unprepared	3.1%	8	3.1%	8	13.0%	33
Somewhat Unprepared	7.5%	19	3.9%	10	9.8%	25
Unsure	5.1%	13	2.4%	6	19.3%	49
Somewhat Prepared	34.1%	87	25.5%	65	35.8%	91
Well Prepared	11.0%	28	65.1%	166	22.0%	56
Total	100.0%	255	100.0%	255	100.0%	254

How Often Skills Are Used:

	Math %	Math N=	Problem Solving %	Problem Solving N=	Set-Ups %	Set-Ups N=
All the Time	51.2%	132	39.5%	102	38.8%	99
Frequently	25.2%	65	28.3%	73	18.0%	46
Occasionally	14.3%	37	16.7%	43	12.9%	33
Rarely	6.6%	17	9.7%	25	10.2%	26
Not at All	2.7%	7	5.8%	15	20.0%	51
Total	100.0%	258	100.0%	258	100.0%	255

	Interpreting %	Interpreting N=	Reading Manuals %	Reading Manuals N=	Reading Gauges %	Reading Gauges N=
All the Time	10.2%	26	9.7%	25	18.9%	48
Frequently	15.2%	39	15.6%	40	18.9%	48
Occasionally	27.7%	71	37.7%	97	27.2%	69
Rarely	20.3%	52	26.1%	67	18.9%	48
Not at All	26.6%	68	10.9%	28	16.1%	41
Total	100.0%	256	100.0%	257	100.0%	254

	Ask Coworker for Help %	N=	Ask Supervisor for Help %	N=	Computer Data Entry %	N=
All the Time	8.1%	21	4.3%	11	9.7%	25
Frequently	21.3%	55	16.5%	42	7.0%	18
Occasionally	47.7%	123	44.3%	113	7.4%	19
Rarely	15.9%	41	21.6%	55	11.6%	30
Not at All	7.0%	18	13.3%	34	64.3%	166
Total	100.0%	258	100.0%	255	100.0%	258

	Operate Computerized Machinery %	N=	Computer Set-Ups %	N=	Computer Diagnostics %	N=
All the Time	9.1%	23	9.3%	24	1.6%	4
Frequently	5.5%	14	5.8%	15	0.8%	2
Occasionally	9.1%	23	5.8%	15	5.5%	14
Rarely	9.1%	23	11.2%	29	10.5%	27
Not at All	67.2%	170	67.8%	175	81.6%	209
Total	100.0%	253	100.0%	258	100.0%	256

	Computer Programming %	N=
All the Time	1.2%	3
Frequently	1.6%	4
Occasionally	4.3%	11
Rarely	8.6%	22
Not at All	84.4%	217
Total	100.0%	257

How Often Will These Skills Be Used in the Year 2000?:

	Math %	N=	Reading %	N=	Interpreting %	N=
Much Less Often	3.1%	8	2.7%	7	2.4%	6
Less Often	17.3%	44	7.5%	19	10.8%	27
No Change	34.1%	87	39.6%	101	43.8%	109
More Often	28.6%	73	31.8%	81	32.5%	81
Much More Often	16.9%	43	18.4%	47	10.4%	26
Total	100.0%	255	100.0%	255	100.0%	249

	Computer Diagnostics %	N=	Computer Data Entry %	N=	Operate Computerized Machinery %	N=
Much Less Often	1.2%	3	1.6%	4	1.2%	3
Less Often	4.8%	12	2.3%	6	1.2%	3
No Change	25.8%	64	17.2%	44	16.4%	41
More Often	42.3%	105	46.1%	118	46.8%	117
Much More Often	25.8%	64	32.8%	84	34.4%	86
Total	100.0%	248	100.0%	256	100.0%	250

	Computer Set-Ups %	N=	Computer Programming %	N=
Much Less Often	2.0%	5	2.4%	6
Less Often	4.0%	10	3.1%	8
No Change	20.2%	51	25.6%	65
More Often	42.7%	108	38.6%	98
Much More Often	31.2%	79	30.3%	77
Total	100.0%	253	100.0%	254

	Technology Changes Will Require Higher Level Reading Skills %	N=	Technology Changes Will Require Higher Level Math Skills %	N=	My Position in the Trade Has Matched My Skill Level %	N=	My Position in the Trade Requires Fewer Skills Than I Have %	N=
Agree	50.6%	130	47.8%	122	36.9%	94	43.9%	111
Unsure	30.4%	78	31.0%	79	32.5%	83	22.1%	56
Disagree	19.1%	49	21.2%	54	30.6%	78	34.0%	86
Total	100.0%	257	100.0%	255	100.0%	255	100.0%	253

	I Would Like to Remain in the Trade %	N=	The Shop Encourages Skill Upgrading %	N=	I Use Skills Acquired in Training %	N=
Strongly Disagree	2.4%	6	5.9%	15	5.6%	14
Disagree	7.5%	19	22.7%	58	10.8%	27
Unsure	26.7%	68	15.3%	39	12.0%	30
Agree	44.7%	114	45.9%	117	61.4%	154
Strongly Agree	18.8%	48	10.2%	26	10.4%	26
Total	100.0%	255	100.0%	255	100.0%	251

	I Can Acquire New Skills on the Job %	N=	I Would Like to Advance My Skills %	N=	I Would Like More Variety in My Job Assignment %	N=
Strongly Disagree	3.5%	9	1.6%	4	3.1%	8
Disagree	5.9%	15	0.4%	1	18.0%	46
Unsure	9.0%	23	8.9%	23	20.7%	53
Agree	65.9%	168	56.0%	144	44.1%	113
Strongly Agree	15.7%	40	33.1%	85	14.1%	36
Total	100.0%	255	100.0%	257	100.0%	256

	Skills From Other Jobs Help Me in This Work %	N=
Strongly Disagree	4.7%	12
Disagree	11.7%	30
Unsure	9.3%	24
Agree	53.7%	138
Strongly Agree	20.6%	53
Total	100.0%	257

Upgrading Courses:

# of Courses	%	N=
One	21.4%	55
Two	3.5%	9
Three	2.7%	7
Four	0.0%	0
Five	0.4%	1
Six	0.4%	1
Seven or More	0.4%	1
None	71.2%	183
Total	100.0%	257

Averages of Selected Questions:

	Total N	=260
Age	33.5	127
Years at Firm	8.15	202
Years in Trade	11.6	201
Starting Salary	$4.96	153
Present Salary	$10.80	135

APPENDIX D

MACHINING: QUESTIONS AND RESPONSES OF ALL MACHINIST SURVEYED

Preparation for First Job:

	Math %	Math N=	Reading %	Reading N=	Interpreting Diagrams, Manuals, & Blueprints %	Interpreting Diagrams, Manuals, & Blueprints N=
Very Unprepared	5.1%	14	6.6%	18	11.7%	32
Somewhat Unprepared	9.5%	26	1.8%	5	14.6%	40
Unsure	7.3%	20	2.9%	8	8.0%	22
Somewhat Prepared	45.5%	125	29.6%	81	44.2%	121
Well Prepared	32.7%	90	59.1%	162	21.5%	59
Total	100.0%	275	100.0%	274	100.0%	274

How Often Skills Are Used:

	Math %	Math N=	Problem Solving %	Problem Solving N=	Set-Ups %	Set-Ups N=
All the Time	53.5%	147	45.5%	125	51.6%	142
Frequently	21.5%	59	24.7%	68	14.2%	39
Occasionally	14.5%	40	17.8%	49	12.0%	33
Rarely	5.5%	15	5.8%	16	6.9%	19
Not at All	5.1%	14	6.2%	17	15.3%	42
Total	100.0%	275	100.0%	275	100.0%	275

	Interpreting %	Interpreting N=	Reading Manuals %	Reading Manuals N=	Reading Gauges %	Reading Gauges N=
All the Time	47.6%	131	11.0%	30	45.2%	122
Frequently	14.5%	40	17.6%	48	20.4%	55
Occasionally	16.7%	46	36.3%	99	18.1%	49
Rarely	8.7%	24	22.0%	60	9.3%	25
Not at All	12.4%	34	13.2%	36	7.0%	19
Total	100.0%	275	100.0%	273	100.0%	270

	Ask Coworker for Help %	N=	Ask Supervisor for Help %	N=	Computer Data Entry %	N=
All the Time	7.7%	21	4.4%	12	8.1%	22
Frequently	13.6%	37	11.7%	32	8.1%	22
Occasionally	45.4%	124	43.4%	119	9.2%	25
Rarely	26.4%	72	30.7%	84	17.3%	47
Not at All	7.0%	19	9.9%	27	57.4%	156
Total	100.0%	273	100.0%	274	100.0%	272

	Operate Computerized Machinery %	N=	Computer Set-Ups %	N=	Computer Diagnostics %	N=
All the Time	14.7%	40	5.5%	15	0.7%	2
Frequently	2.9%	8	1.1%	3	1.5%	4
Occasionally	9.5%	26	3.3%	9	4.1%	11
Rarely	8.4%	23	10.3%	28	8.2%	22
Not at All	64.5%	176	79.8%	217	85.4%	229
Total	100.0%	273	100.0%	272	100.0%	268

	Computer Programming %	N=
All the Time	4.4%	12
Frequently	0.4%	1
Occasionally	5.5%	15
Rarely	7.7%	21
Not at All	81.9%	222
Total	100.0%	271

How Often Will These Skills Be Used in the Year 2000?:

	Math %	N=	Reading %	N=	Interpreting %	N=
Much Less Often	4.0%	11	1.8%	5	1.5%	4
Less Often	11.3%	31	5.8%	16	10.9%	30
No Change	23.0%	63	26.6%	73	29.8%	82
More Often	30.7%	84	36.1%	99	34.9%	96
Much More Often	31.0%	85	29.6%	81	22.9%	63
Total	100.0%	274	100.0%	274	100.0%	275

	Computer Diagnostics %	N=	Computer Data Entry %	N=	Operate Computerized Machinery %	N=
Much Less Often	2.9%	8	1.5%	4	1.5%	4
Less Often	3.3%	9	2.6%	7	3.3%	9
No Change	15.1%	41	9.9%	27	8.1%	22
More Often	31.3%	85	36.5%	100	27.5%	75
Much More Often	47.4%	129	49.6%	136	59.7%	163
Total	100.0%	272	100.0%	274	100.0%	273

	Computer Set-Ups %	N=	Computer Programming %	N=
Much Less Often	2.6%	7	3.3%	9
Less Often	3.6%	10	2.2%	6
No Change	14.6%	40	12.0%	33
More Often	32.8%	90	31.6%	87
Much More Often	46.4%	127	50.9%	140
Total	100.0%	274	100.0%	275

	Technology Changes Will Require Higher Level Reading Skills %	N=	Technology Changes Will Require Higher Level Math Skills %	N=	My Position in the Trade Has Matched My Skill Level %	N=	My Position in the Trade Requires Fewer Skills Than I Have %	N=
Agree	65.6%	181	68.8%	190	34.5%	95	37.6%	103
Unsure	22.8%	63	19.6%	54	29.1%	80	33.2%	91
Disagree	11.6%	32	11.6%	32	36.4%	100	29.2%	80
Total	100.0%	276	100.0%	276	100.0%	255	100.0%	274

	I Would Like to Remain in the Trade %	N=	The Shop Encourages Skill Upgrading %	N=	I Use Skills Acquired in Training %	N=
Strongly Disagree	4.8%	13	6.6%	18	5.5%	15
Disagree	5.1%	14	17.9%	49	12.5%	34
Unsure	23.8%	65	15.0%	41	14.7%	40
Agree	46.5%	127	48.0%	131	53.7%	146
Strongly Agree	19.8%	54	12.5%	34	13.6%	37
Total	100.0%	273	100.0%	273	100.0%	272

	I Can Acquire New Skills on the Job %	N=	I Would Like to Advance My Skills %	N=	I Would Like More Variety in My Job Assignment %	N=
Strongly Disagree	7.3%	20	1.8%	5	4.4%	12
Disagree	11.7%	32	0.4%	1	6.6%	18
Unsure	8.0%	22	4.8%	13	16.1%	44
Agree	59.5%	163	64.0%	174	55.5%	152
Strongly Agree	13.5%	37	29.0%	79	17.5%	48
Total	100.0%	274	100.0%	272	100.0%	274

	Skills From Other Jobs Help Me in This Work %	N=
Strongly Disagree	3.7%	10
Disagree	10.6%	29
Unsure	8.1%	22
Agree	60.8%	166
Strongly Agree	16.8%	46
Total	100.0%	273

Upgrading Courses:

# of Courses	%	N=
One	22.9%	63
Two	9.5%	26
Three	4.4%	12
Four	0.7%	2
Five	0.7%	2
Six	0.7%	2
Seven or More	1.5%	4
None	59.6%	164
Total	100.0%	275

Averages of Selected Questions:

	Total N	=277
Age	34.9	168
Years at Firm	7.33	232
Years in Trade	11.4	226
Starting Salary	$5.33	205
Present Salary	$11.90	183

APPENDIX E

AUTO REPAIR QUESTIONS AND RESPONSES OF ALL AUTO REPAIR TECHNICIANS SURVEYED

Preparation for First Job:

	Math		Reading		Interpreting Diagrams, Manuals, & Blueprints	
	%	N=	%	N=	%	N=
Very Unprepared	3.2%	6	3.7%	7	5.4%	10
Somewhat Unprepared	6.4%	12	3.7%	7	9.7%	18
Unsure	5.9%	11	4.8%	9	15.7%	29
Somewhat Prepared	34.8%	65	31.0%	58	36.2%	67
Well Prepared	49.7%	93	56.7%	106	33.0%	61
Total	100.0%	187	100.0%	187	100.0%	185

How Often Skills Are Used:

	Math		Problem Solving		Set-Ups	
	%	N=	%	N=	%	N=
All the Time	25.4%	48	60.4%	113	22.5%	42
Frequently	29.6%	56	25.7%	48	28.9%	54
Occasionally	34.4%	65	8.6%	16	26.2%	49
Rarely	8.5%	16	2.7%	5	12.3%	23
Not at All	2.1%	4	2.7%	5	10.2%	19
Total	100.0%	189	100.0%	187	100.0%	187

	Interpreting		Reading Manuals		Reading Gauges	
	%	N=	%	N=	%	N=
All the Time	27.7%	52	40.4%	76	43.3%	81
Frequently	29.3%	55	35.1%	66	36.4%	68
Occasionally	25.0%	47	18.6%	35	14.4%	27
Rarely	9.6%	18	4.3%	8	2.1%	4
Not at All	8.5%	16	1.6%	3	3.7%	7
Total	100.0%	188	100.0%	188	100.0%	187

	Ask Coworker for Help %	N=	Ask Supervisor for Help %	N=	Computer Data Entry %	N=
All the Time	10.8%	20	5.1%	9	7.6%	14
Frequently	24.3%	45	19.4%	34	14.1%	26
Occasionally	44.9%	83	38.3%	67	20.5%	38
Rarely	17.3%	32	28.0%	49	21.1%	39
Not at All	2.7%	5	9.1%	16	36.8%	68
Total	100.0%	185	100.0%	175	100.0%	185

	Operate Computerized Machinery %	N=	Computer Set-Ups %	N=	Computer Diagnostics %	N=
All the Time	18.4%	17	4.4%	8	18.4%	34
Frequently	13.4%	25	7.1%	13	23.2%	43
Occasionally	14.0%	26	13.7%	25	17.8%	33
Rarely	19.9%	37	16.4%	30	11.4%	21
Not at All	43.5%	81	58.5%	107	29.2%	54
Total	100.0%	186	100.0%	183	100.0%	185

	Computer Programming %	N=
All the Time	3.2%	6
Frequently	4.8%	9
Occasionally	5.4%	10
Rarely	19.9%	37
Not at All	66.7%	124
Total	100.0%	186

How Often Will These Skills Be Used in the Year 2000?:

	Math %	N=	Reading %	N=	Interpreting %	N=
Much Less Often	5.5%	10	3.3%	6	3.4%	6
Less Often	4.9%	9	1.1%	2	2.8%	5
No Change	15.8%	29	14.9%	27	12.8%	23
More Often	39.9%	73	35.4%	64	32.4%	58
Much More Often	33.9%	62	45.3%	82	48.6%	87
Total	100.0%	183	100.0%	181	100.0%	179

	Computer Diagnostics %	N=	Computer Data Entry %	N=	Operate Computerized Machinery %	N=
Much Less Often	4.9%	9	3.9%	7	4.9%	9
Less Often	0.5%	1	2.2%	4	1.1%	2
No Change	8.7%	16	10.5%	19	17.9%	55
More Often	25.1%	46	46.4%	84	38.6%	71
Much More Often	60.7%	111	37.0%	67	37.5%	69
Total	100.0%	183	100.0	181	100.0%	184

	Computer Set-Ups %	N=	Computer Programming %	N=
Much Less Often	8.9%	16	6.6%	12
Less Often	2.2%	4	2.8%	5
No Change	30.7%	55	27.1%	49
More Often	31.3%	56	31.5%	57
Much More Often	26.8%	48	32.0%	58
Total	100.0%	179	100.0%	181

	Technology Changes Will Require Higher Level Reading Skills %	N=	Technology Changes Will Require Higher Level Math Skills %	N=	My Position in the Trade Has Matched My Skill Level %	N=	My Position in the Trade Requires Fewer Skills Than I Have %	N=
Agree	75.7%	137	69.9%	128	37.9%	69	27.5%	49
Unsure	18.8%	34	24.0%	44	30.8%	56	24.7%	44
Disagree	5.5%	10	6.0%	11	31.3%	57	47.8%	85
Total	100.0%	181	100.0%	183	100.0%	182	100.0%	178

	I Would Like to Remain in the Trade %	N=	The Shop Encourages Skill Upgrading %	N=	I Use Skills Acquired in Training %	N=
Strongly Disagree	3.2%	6	3.2 %	6	1.1%	2
Disagree	6.3%	12	10.1%	19	5.3%	10
Unsure	24.7%	47	8.5%	16	6.9%	13
Agree	41.6%	79	59.8%	113	67.7%	128
Strongly Agree	24.2%	46	18.5%	35	19.0%	36
Total	100.0%	190	100.0%	189	100.0%	189

	I Can Acquire New Skills on the Job %	N=	I Would Like to Advance My Skills %	N=	I Would Like More Variety in My Job Assignment %	N=
Strongly Disagree	2.7%	5	0.5%	1	2.7%	5
Disagree	4.8%	9	0.5%	1	7.1%	13
Unsure	6.4%	12	3.7%	7	25.0%	46
Agree	65.4%	123	55.3%	104	53.8%	99
Strongly Agree	20.7%	39	39.9%	75	11.4%	21
Total	100.0%	188	100.0%	188	100.0%	184

	Skills From Other Jobs Help Me in This Work %	N=
Strongly Disagree	2.7%	5
Disagree	11.4%	21
Unsure	11.9%	22
Agree	49.7%	92
Strongly Agree	24.3%	45
Total	100.0%	185

Upgrading Courses:

# of Courses	%	N=
One	42.7%	76
Two	18.0%	32
Three	6.7%	12
Four	2.8%	5
Five	0.6%	1
Six	0.6%	1
Seven or More	1.1%	2
None	34.3%	61
Total	100.0%	178

Averages of Selected Questions:

	Total N =192	
Age	33.3	106
Years at Firm	6.72	140
Years in Trade	13.2	143
Starting Salary	$2.26	115
Present Salary	$12.70	108