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ABSTRACT

Technological advances necessitate the continuous retraining of the work force. Three technologies are having greatest impact on the labor force: (1) the scope and depth of computer skills required by most jobs continue to expand; (2) robotics in manufacturing means that certain new jobs are more technical and require postsecondary education; and (3) telecommunications are becoming increasingly important in business. Consequently, a large proportion of workers is likely to be affected by one or more of these technologies. Three general effects of new technologies are skill twist, deskilling, and upskilling. Skill twist refers to the displacement of old skills with new ones. In deskilling, new technology reduces the level of skills required, and upskilling has the opposite effect. The nature of retraining for these three effects clearly differs; other influences are employee characteristics and organizational structures. Strategies for retraining include lifelong learning, use of educational technology, training sponsored by professional organizations, and vendor training materials. Issues in their use include affordability, accessibility, effectiveness, and the question of who is responsible--individuals or employers. Different policies are needed for skill twist, deskilling, and upskilling, as well as attention to the needs of groups whose level of literacy or economic circumstances limit their ability to participate in retraining. (33 references) (SK)

8b. INTRODUCING NEW TECHNOLOGY INTO THE WORKPLACE: RETRAINING ISSUES AND STRATEGIES

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8b. INTRODUCING NEW TECHNOLOGY INTO THE WORKPLACE: RETRAINING ISSUES AND STRATEGIES

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I. BACKGROUND

Technological advance has changed the methods of production in a wide variety of industries. It has created many situations in which machines can, to some extent, be substituted for workers. In some cases where this substitution takes place, sophisticated machinery is used in place of low-skill workers and in other cases the machinery is used in place of relatively high-skill workers. In almost all cases, however, this substitution requires some retraining of workers. This report summarizes the available information on the best methods for introducing new technology into the workplace. Of particular interest are techniques that can be used for continuously retraining the existing workforce.

The impact of technology on jobs and workers is an enduring and well studied topic (e.g., Burke & Rumberger, 1987; Cyert & Mowery, 1987; Ginzberg, Noyelle & Stanback, 1986; Leontief & Duchin, 1986; Rosenberg, 1966; Rothweel & Zegveld, 1979; Shaiken, 1985). These studies have primarily focused on quantifying the number of workers likely to be displaced by technology or the number of new jobs likely to be created. They have not addressed the central issue of this study which is how to retrain people affected by technology. In particular, the current effort focuses on the impact of three major technologies: computers, robotics and telecommunications. These three technologies are likely to affect most workers in the coming decades.

The remainder of this introductory section summarizes the literature on training for computer, robotic and telecommunications technology. The next section discusses the impact of these three technologies on the workplace in terms of job skills and knowledge. Section III presents a framework for analyzing the retraining needs caused by technology. Strategies for retraining are described in Section IV. The final section outlines conclusions and policy recommendations based upon the preceding analysis.

In general, there is not a lot known about how to best train workers for specific technologies. Most of the studies of how to teach people to use computers have focused on word processing systems in office environments (e.g., Carroll, 1982; Goldstein & Fraser, 1986). These studies suggest that effective computer training must be task-oriented and involve considerable hands-on practice. Studies also indicate that most people have an "action-orientation" when learning to use a computer, i.e., they want to try things out and obtain instruction as needed. It appears that the most common form of computer training on the job is self learning using the documentation provided with the system rather than formal classroom instruction.

By contrast, there has been a sustained effort in this decade to introduce "computer literacy" as a general skill in elementary/secondary education (Seidel, Hunter & Anderson, 1982). While originally conceptualized as a need for all students to learn to program, the focus of computer literacy efforts in today's classrooms is on the use of general purpose programs such as word processing or database programs throughout the curriculum. Thus, there is some reason to believe that the current cohort of students graduating from secondary school are more knowledgeable about computers than earlier graduates and hence will be better prepared to use computers in the workplace.

While there has been a lot of discussion of robotics in the technical literature and popular press, there has been little written about training for robotics. Husband (1986) provides a collection of articles about education and training for robotics. Under the auspices of the Dept. of Education, Office of Vocational and Adult Education, a curriculum for robotic/automated systems technicians (RAST) has been established. In an 1984 survey, there were 56 post-secondary institutions providing RAST programs with another 114 schools offering some form of robotics courses (Hull & Lovett, 1988). On-the-job training for robotics is primarily provided by the robot manufacturers in the form of workshops and short courses. The available evidence suggests that most workers learn to actually operate or maintain robots in the workplace through one-on-one guidance from another employee (e.g., plant engineer) or the manufacturer's representative.

Kearsley (1985a) describes the nature of current training efforts in the telecommunications industry. To address the basic educational needs of telecommunication technicians, the National Telecommunications Education Council, under the auspices of the North American Telecommunications Association, has established a curriculum adopted by many community and technical colleges. On-the-job training is provided by internally-developed courses and some courses provided by equipment manufacturers. "Over the shoulder" training is widely used in the telecommunications industry. Most telecommunications companies are exploring technology-based approaches to training, including computer simulations and video in order to reduce costs and training time.

To summarize, training for technology can be divided into an educational component and an on-the-job component. The education component is addressed by programs at post-secondary institutions (primarily community and technical colleges) and at the primary/secondary level for basic computer knowledge. In the case of robotics and telecommunications, curriculum guidelines have been established for technician courses. On-the-job training involves courses provided by equipment manufacturers as well as company-developed courses. Apprenticeship of one form or another plays an important role in robotics and telecommunications training. A large percentage of on-the-job computer training appears to involve self learning.

Beyond these general conclusions, little detailed information is available about retraining programs or results as they pertain to new technology. We do not know how much retraining is conducted, how and when it is conducted, or what works and what doesn't. Hence, it is necessary to speculate about how retraining for technology might be conducted. These speculations are based upon discussions with individuals responsible for large scale retraining programs in different companies and an understanding of the kinds of skills and knowledge associated with the technologies discussed. To turn these speculations into substanciated facts, it would be necessary to conduct empirical studies of retraining programs in industry and government organizations.

II. THE TECHNOLOGIES

The first step in analyzing the types of retraining needed for technology is to consider the types of new skills and knowledge associated with these technologies.

Computers

Computers, in one form or another, have come to dominate the workplace (Blissmer & Alden, 1988; Anderson & Sullivan, 1988). They affect all levels of workers from the semi-skilled clerk who operates a computerized cash register (technically called a "Point of Sale" system) to the senior manager who uses spreadsheets to do financial projections. Small businesses use personal computers for accounting and billing. In large corporations, computerized systems handle a myriad of functions including employee and customer records, inventory, production control, and almost all financial activities.

Some computer applications have broadly affected many types of people. For example, word processing has required most secretaries, writers, and professionals to become "computer literate." Automated bank teller machines (ATMs) have gotten consumers used to the idea of computerized cash transactions. Airline, hotel, and car rental reservation systems have conditioned the traveling public to information retrieval systems. In short, it is becoming increasingly difficult to function as either an employee or consumer in our society without substantial interaction with computers.

New kinds of software applications may have an even more profound impact on certain jobs and professions. In the engineering profession, Computer Aided Drafting (CAD) and Computer Aided Manufacturing (CAM) systems are dramatically changing the nature of engineering competence. To be a good engineer today, it is necessary to be able to use CAD/CAM systems well. Desktop publishing systems are changing the way all types of publications are created and produced affecting the jobs of printers, graphics designers, editors, and writers. In most large organizations, desktop publishing has changed the workflow and responsibilities of training, marketing, and printing departments.

Expert systems are likely to affect many types of professionals including physicians, financial analysts, lawyers, and managers (Harmon

& King, 1985). Expert systems are also likely to significantly influence most maintenance and service activities. Using expert systems, it becomes possible to package and distribute the experience and judgement of selected individuals or groups. For the first time, it becomes possible to automate (at least partially) the jobs of specialists and senior level employees rather than just entry level positions.

While the number of people employed as programmers is not likely to increase dramatically in the future, the number of people involved in the design and implementation of computer software and systems is projected to increase significantly. Thus, computer-related occupations will become very numerous. Furthermore, there is a clear trend in software towards "extensible" systems that allow users to create their own customized programs using high-level languages. While there may not be an increase in programming as an occupation, it appears that many computer users will engage in some form of programming activity as a normal course of events.

To summarize, the scope and depth of computer skills required by most employees to do their job continues to expand. Historically, computer skills were confined to those individuals directly involved in the computer field (such as programmers or computer operators). Now, a familiarity with computers is needed for many jobs. In the future, it seems likely that almost every employee will need to be retrained to use computers in some fashion.

In the manufacturing arena, the impact of robotics on jobs has been well documented (e.g., Ayres & Miller, 1983; Hunt & Hunt, 1983; Miller, 1988). Certain types of jobs such as machine operators and trades such as metalworking are subject to significant displacement by robot systems since they involve tasks that the current generation of robots can perform. As robots become more sophisticated, they are likely to impact a wider variety of factory jobs and trades. At the same time, robots create a need for maintenance technicians, programmers, and supervisors. The majority of jobs associated with robotics are technical and require a post-secondary education. This contrasts with the background and educational levels of workers displaced by robotic systems who often have a high school background at best.

Robotics has had a major impact on the engineering profession. Manufacturing and industrial engineers need to understand robotic systems thoroughly in order to design automated factories and products that can be processed properly by robots. In addition, engineers need to understand the electronic and mechanical characteristics of robots in order to develop operating and maintenance procedures.

Even without robots, the factory floor is undergoing a major transformation due to increased computerization. Microprocessor controlled sensors and switches allow manufacturing processes to be controlled by programs rather than the human eye. Operators often monitor production by watching computer displays rather than the actual assembly lines. Managers study print-outs from Manufacturing Report Programs (MRPs) to assess quality control and production problems. Together, all of these developments in technology have dramatically altered the nature of factory work for skilled, unskilled, and professional employees.

Telecommunications

The impact of telecommunications technology is more subtle than either computers or robotics, but equally pervasive. Consider the impact of cellular telephone service; it has created new marketing, maintenance, installation, and service opportunities. Major changes in transmission technologies such as fiber optics satellites, and ISDN (digital networks) are creating needs for new engineering, maintenance and service procedures. Ultimately, the impact trickles down to all employees and consumers when they start to use these new technologies.

Much of this impact is felt directly in the business world. For example, facsimile devices have become popular very quickly in medium and large-sized companies. This means that most employees now need to learn how to operate a fax machine as a general office skill. In the meantime, telephones are becoming more complex due to added features such as answering machines, call forwarding, automatic dialing, conference calling, etc. Since there is rarely any formal training provided for these systems, people must teach themselves using any documentation provided by the equipment manufacturer.

Computer networks (which combine computer and telecommunications technology) are likely to affect many people. For example, electronic mail is becoming widely used in the scientific community and in large organizations for day-to-day communication. Videoconferencing (which blends television and telecommunications technology) becomes more popular as satellite transmission costs decrease. Computer networking and videoconferencing technologies change the way people interact and are managed (Hiltz, 1984).

Extent of Impact

Computers, robotics, and telecommunications technologies could broadly alter the nature of work at all levels over the next decade. While technology change is nothing new, the magnitude of the change caused by these three technologies is. A large proportion of the U.S. workforce is likely to be affected in some way by one or more of these technologies, resulting in a major overhaul of job skills and responsibilities across all occupations. This could produce retraining needs of epic proportions, similar in magnitude to the introduction of electricity or automobiles. However, unlike past technologies, the new information age technologies are likely to become entrenched faster and affect more people (Naisbitt, 1980; Toffler, 1980). What we do not know is how many people will be affected or exactly how.

It is worth noting that retraining is not only the solution to meeting new job requirements caused by technology. Many organizations will lay off or retire existing employees and replace them with workers who are already trained in the technologies involved. However, most organizations recognize that this is a more expensive strategy in the long-term than retraining (Rosow & Zager, 1987). Companies may also relocate in order to tap a better trained labor pool. This is also likely to be more expensive than retraining. Even if companies follow alternative strategies to retraining, the displaced workers still have to find jobs and hence deal with retraining on an individual basis.

III. RETRAINING NEEDS

The introduction of technology into the workplace can have three general effects in terms of impact on employees: skill twist, deskilling, and upskilling. Each one of these effects has different implications for retraining.

Skill Twist

Skill twist refers to the change in required job skills when technology is introduced; old skills are displaced by new ones. For example, when robots are used for assembly of components instead of human operators, manual assembly skills are displaced by the need for robot maintenance and supervision skills. When CAD/CAM is used for engineering applications, drafting skills are no longer needed but an understanding of computer graphics and output devices (e.g., plotters) is necessary. When an organization switches to fiber optic or digital telecommunications, installation and service skills change from analog to digital circuits.

Skill twist situations are usually problematic from a retraining perspective because the new skills and knowledge required is usually quite different from the old. This raises the issue of whether the existing worker has the ability/inclination to learn such different skills. For example, the physical skills of assembling, welding, or riveting are totally different from the mental skills of robot programming, maintenance and design. The type of testing and installation associated with digital communications is quite different from those involved in analog telephony. Word processing and desktop publishing involve a lot of abstraction and conceptualization tasks compared to the physical and concrete operations of typewriters and typesetting equipment. Employees caught in skill twist situations often require lengthy re-education starting with the basic concepts of the new technology.

Deskilling

Deskilling describes the situation in which new technology reduces the level of skills required to do a job. For example, when a robot is used to spray paint, the human operator may only be needed as a caretaker to refill paint tanks, replace nozzles, and clean up the work site. When point-of-sale systems are installed in fast food restaurants, the counter attendants only need to push the right buttons -- the system takes care of totaling the bill, calculating change, and placing the order with the kitchen. With an automated teller machine, all cash transactions are performed by the system; a human operator is needed only to load cash and remove deposit envelopes.

One common effect of deskilling is that the employee takes on a broader range of simpler tasks. Because automation reduces the amount of attention and time needed for each task, it is possible to assign more tasks to a given worker. Thus, deskilling may create the situation where the employee has greater responsibility in terms of scope of activities even though each activity is relatively simple.

Deskilling can have significant emotional consequences since the employee may suffer loss of self-esteem due to reduction of job responsibility and challenge. Indeed the employee's job may be downgraded from a skilled position to a semi or unskilled position with corresponding pay decrease. Under these circumstances, reassignment (or even termination) may seem more preferable to the employee than retraining. However, without retraining, displaced workers are not likely to do any better. For example, an OTA study reports that half of the workers who found jobs after layoffs experienced pay cuts (Office of Technology Assessment, 1987).

Upskilling

Upskilling occurs when technology increases the level of skills required to do a job. When a secretary or writer starts using a desktop publishing program, knowledge of page layout, typography, and printing will be needed. When a manager or scientist starts to use electronic mail or online databases, a general understanding of computer communications is required. When a factory supervisor is asked to monitor robots, new set-up, safety and troubleshooting procedures are involved.

Upskilling means that the employee must learn new skills that extend their present tasks and responsibilities. There is a danger that employees may become overloaded and highly stressed as they try to accommodate the new tasks. Furthermore, any training needed must fit into the existing job regime since the new tasks are likely to build upon the old. An engineer learning to use a CAD/CAM system must still turn out specifications even while learning; a nurse must still keep proper records while learning how to use a patient management system; a manager must still keep a project on track while learning to use an electronic conferencing system.

Nature of Retraining Needed

The nature of the retraining required will vary with the way the new technology affects the job. In the case of skill twist, the retraining is likely to be lengthy and involve fundamentally new knowledge. Retraining of this type is likely to require a full-time learning program spanning many months or years. Deskilling situations may involve little formal training but considerable employee counseling. Upskilling requires ongoing training programs that can fit in with the job, either as on-site training or continuing education programs.

Regardless of the nature of the retraining involved, most training associated with technology will require considerable "hands-on" activity. Learning to use computers, robots or telecommunications involves procedural skills and knowledge that are best acquired while practicing with the equipment (either actual or simulated). For this reason, traditional classroom instruction (i.e., lecture or seminars) has limited utility in training for technology unless it is supplemented by laboratory sessions (Seidel & Kearsley, 1987).

It is also important to emphasize that retraining programs of any type deal with adult education. This means the use of teaching activities that build upon the experiences of the learner and involve group interaction (Knowles, 1984). Credibility of instructors and fidelity of the instructional materials is also critical. The relevance of the instruction to the career goals of students needs to be clear to maintain interest and motivation.

The distinction between a skill twist, deskilling or upskilling situation for a given job will depend upon the individual. What represents a skill twist for one person may be an upskilling situation for another, or vice-versa. For example, the switch to CAD/CAM may not be a major change for a young engineer already familiar with computers but may involve totally new skills for an older engineer with no computer experience. Furthermore, a job may be redefined so that it involves a combination of deskilling, skill twist, and upskilling aspects (Kraut, Dumais, & Koch, 1989). Assessments of retraining needed must be specific to the employee and the job.

Employee Characteristics

Regardless of what kind of retraining situation is involved, there are some general characteristics of technology that create similar skill demands across all jobs (see Carnevale et al., 1988). Using and understanding technology requires a problem-solving, methodological type of ability. To successfully work with hi-tech systems, it is necessary to analyze and reason about why things work or don't work. Because most hi-tech systems are complex to operate and maintain, a lot of documentation is involved. This requires good reading skills. Finally, hi-tech equipment tends to have short life cycles. For example, most computer systems (both hardware and software) tend to last only 3-5 years before being replaced. Consequently, the retraining process can be frequent -- occurring regularly every few years. Indeed, in some professions such as medicine, engineering or data processing, the half-life of job knowledge is only 2-3 years and continuous retraining is necessary (Bell, 1976).

Employees need to have a high level of basic literacy (reading/writing/listening) skills to cope satisfactorily with retraining needs. In addition, they need to have good problem-solving and reasoning skills. Certain personality characteristics (e.g., flexibility, high self-esteem) are also critical to the retraining process. However, the most fundamental ability necessary for retraining is the willingness to learn. Technological change demands an almost constant state of learning. Workers at all levels must be able to deal with this. Clearly, this presents problems for that portion of the population that has been turned off by formal education programs.

Organizational Effects

While most of the analysis so far has focused on the individual, retraining needs can also have profound effects on the entire organization. When a significant number of jobs are redefined (or a single job held by many employees), the way the company operates must also be changed. Planning for and implementing retraining can take significant effort and involve many departments and levels of management (Miller, 1989).

By way of example, consider what happens when an aerospace company wins a large contract for a new fighter plane or space vehicle. Hundreds of engineers, scientists, technicians, and manufacturing workers are reassigned or hired. An equal number of administrative staff, managers, and consultants are probably involved. There is a sudden and acute demand for retraining as the technical staff tries to assemble the skills and knowledge needed to carry out the new project. This can range from CAD or automated manufacturing expertise to basic management or communication skills. Retraining activities may extend for years in a lengthy project. When the project is completed, many of the employees will face reassignments or layoffs and possibly a new cycle of retraining.

This example highlights one of the fundamental issues of the retraining problem: who has primary responsibility for retraining -- the individual or the organization? Clearly, organizations are in a position to predict their work force requirements and hence plan retraining programs that meet these needs. However, organizations are not compelled to retrain unless it makes economic sense. In so far as retraining improves the employability and earning power of an individual, it would seem to be a personal matter. In many cases, retraining is initiated by individuals, with or without the support of their employer. In skill twist and deskilling situations, it would seem that responsibility for retraining lies primarily with the organization whereas in upskilling situations, the responsibility is typically borne by the individual.

At the present time, relatively few organizations have devoted significant attention to retraining needs and issues. Motorola provides an example of a company that has specifically focused on retraining by creating a Center for Continuing Education with a mission to provide retraining for employees at all levels (Galagan, 1986). On the hand, many companies only develop retraining programs tc respond to acute events -- such as a plant shutdown or major new products/projects. Clearly, there are different types of organizational responses to retraining just as there as different types of individual needs.

IV. STRATEGIES FOR RETRAINING

A variety of different strategies are needed to deal with the retraining problems just discussed. Like most complex sociotechnical issues, no single strategy or approach will work. A successful retraining plan or policy will require attention to multiple dimensions simultaneously.

Lifelong Learning

The concept of schooling that is still prevalent in the minds of most workers (including educators) is the "red schoolhouse" model -- education is something accomplished when young through mandatory school attendance. It is completed upon entering the workforce. However, this model no longer matches reality for a large portion of the population engaged in "continuing education". Almost every college and university in the U.S. has an active extension program during the evenings and weekends.

The continuing education programs provided by community colleges and university extension departments address retraining needs of the skill twist type where dedicated learning activities are needed. Such programs tend to be fairly responsive to technological change and are usually taught by professionals at the forefront of such technology. For example, soon after robotics became a major force in U.S. manufacturing in the early 1980's, colleges began to offer a wide variety of robotics technician courses. Similarly, programs in areas such as CAD/CAM, desktop publishing, NMR Spectroscopy, fiber optics, etc. appeared shortly after these technologies showed up in the workplace.

As the population ages, colleges and universities will increasingly focus on continuing education programs, driven by market forces to keep their institutions alive. The main problem with this form of retraining is the question of who pays. Individuals engaged in full-time retraining do not usually have the money to cover their tuition and living expenses. It is necessary for the employer, union or government to pay these costs, either through direct subsidy or via loans. Otherwise, the worker is likely to settle for unemployment benefits and any job that can be obtained.

Technology Based Training

Retraining is a normal course of events for any company that markets new products on a regular basis. For example, every year all of the automotive companies must retrain their entire sales and service staff about the new models. Consumer electronics, computer, and telecommunications companies are continually introducing new products that require large-scale retraining of their workforce. The U.S. military is constantly upgrading its weapons systems and retraining its personnel. The majority of these retraining programs focus on upskilling in the context of organization-specific products, services, or procedures.

Even though retraining is business as usual for all of these organizations, there are many problems. The pace and magnitude of technological change makes retraining via traditional classroom means, more expensive and more lengthy than many organizations can afford. There is also an information overload problem. The amount of information that employees may need to know in order to do their job is beyond their capacity. Furthermore, the basic literacy skills of many employees are weak making it difficult for them to retrain quickly.

In response to these problems, training departments have begun to look for new instructional techniques and/or delivery mechanisms. Computer-based instruction which has been shown to reduce the amount of training time significantly relative to classroom instruction is one avenue being explored. Interactive video which can minimize the reading level requirements and increase the motivation for learning, is being examined. Systems that reduce the need for formal training programs are being tried. Video and audio conferencing methods are being used to reduce the need for travel to training sites. In short, industry is attempting to use technology itself to deal with the increased retraining needs caused by technology (see Kearsley, 1985b).

Professional Organizations

Many professionals including health care workers, engineers, scientists, lawyers, architects, educators, and financial analysts receive a major portion of their retraining from attendance at conferences or workshops sponsored by professional organizations they belong to. Such meetings provide information on very specialized topics and tend to cover new developments before they are widely disseminated. They may be held nationally or regionally and deal with global or local concerns.

The quality of retraining received by professionals through this channel has important side effects on the continuing education programs offered by colleges and universities in so far as a large proportion of the instructors are drawn from the ranks of professionals. If attendance at professional meetings improves the knowledge of professionals about new technology, this will be reflected in the courses they teach.

The major problem with this channel of retraining is that it does not reach all professionals equally. Some professionals are reluctant to take the time or spend the money needed for attendance at meetings.

Professionals in metropolitan centers tend to have more opportunities for workshops and meetings than those in outlying areas. There is a need to make participation in these activities more independent of geography and time schedules. Packaging these meetings in video form would help, as would the use of video/computer conferencing.

Vendor Training Materials

In many cases, the technology that necessitates retraining is supplied by an outside vendor who carries some or all of the responsibility for training. This training varies considerably in quality depending upon the importance the vendor and customer accord to it. Often the training is poorly produced or delivered since it is viewed by the vendor as an expense that detracts from profits. Ironically, vendor training is frequently the main form of retraining provided, especially in upskilling situations where no other training is available to the employee.

Some vendors have attempted to provide high quality training at an affordable cost by exploring multimedia self-study approaches. These training packages consist of workbooks, videotapes, and sometimes, computer-based instruction modules, that allow employees to learn on the job at their own pace. Such self study approaches avoid the cost of instructors and training facilities, (although they can be expensive to develop) and match the needs of employees and employers for on-site retraining.

Quality and acceptability of vendor materials is usually judged by the customer, i.e., the organization that purchases the training. However, since the organization often has no expertise in the training area, it is a poor judge of the training quality. Instead, training programs and materials need to be reviewed and approved by professional organizations. In addition, certification exams tied to explicit competencies would assure that vendor training meets acceptable standards. Training courses and materials developed for Department of Defense and government agencies often must meet well-defined specifications and hence are better in quality than courses and materials developed strictly for the commercial sector. This suggests that standards can have a positive effect in improving training materials.

Affordability, Accessibility and Effectiveness

To summarize this discussion of retraining strategies, there are a number of different ways in which retraining for technology can be accomplished, none of which appear to be very effective at present. Continuing education programs provided by colleges and universities address the retraining needs involved in skill twist situations. The major obstacle to this form of retraining is funding. The workers who most often need such retraining (i.e., blue collar, lower middle class) are least able to afford it.

To meet the upskilling type of retraining needs, companies are exploring a variety of technology-based training approaches that can overcome the time and geographical limitations associated with learning on the job. In addition, vendors are increasingly turning to multimedia training materials for the same reason. Professionals receive much or their retraining via attendance at meetings -- an approach which produces uneve results across the workforce. Many professionals are reluctant to take the time necessary to participate in such meetings, especially when it will involve significant travel.

For some workers, primarily those caught in skill twist situations, the major problem with retraining is one of affordability. The training programs exist but without financial assistance they simply have no way to pay for them. For other workers, the problem is not money but accessibility. In many upskilling situations, employees can not find the time to go to training programs that they desperately need. The solution for these people involves bringing the training to the emplcyee. Finally, there is the problem of effectiveness; many of the vendor supplied courses and materials used for retraining do not work well. Standards for on-the-job training are necessary to ensure that courses and materials accomplish what they are supposed to teach.

To address the retraining problem brought about by the emergence of new technologies in the workplace, we need private and government programs that deal with the affordability, accessibility, and effectiveness issues. The next section provides conclusions and recommendations along these lines.

V. CONCLUSIONS & RECOMMENDATIONS

For employees affected by a skill twist situation, the continuing education system provides a satisfactory retraining approach provided that the employee has the necessary literacy and motivation to attend classes. The cost of tuition and living expenses needs to be borne by the employer, union or government since in most cases, the individual can not afford to go to school without a subsidy. Tax incentives for employers and employees and/or educational loans seem essential to make this approach succeed.

Policy options:

1. Recreate the tax incentives previously available to individuals and organizations for educational programs.

2. Create an educational loan program specifically for adults who are entering retraining programs.

3. Require companies/unions to provide salary as well as tuition assistance for employees who enter retraining programs.

Employees in upskilling situations depend primarily on training provided by their own organization or a vendor. This an area where technology-based training approaches could lead to improvements in retraining success. The use of computer-based instruction, interactive video, and multimedia materials has been shown to save training time and provide more motivating instruction. However, development and implementation of hi-tech training is expensive and requires considerable expertise. More support for technology-based training approaches from senior management within organizations is needed to increase its popularity. Leadership by government agencies in this area would be a valuable contribution.

Policy Options:

4. Designate a certain proportion of training funds in government agencies for the use of technology-based training approaches.

5. Increase the technological sophistication of government training specialists so they are able to initiate and manage technology-based training projects.

6. Provide matching funds to state agencies or private corporations to explore technology-based training projects.

A significant problem with the training courses and materials provided by vendors in the commercial sector is that they do not have to meet any objectively defined quality criteria. This could be improved through certification testing under the jurisdiction of unions, professional organizations or state agencies. For example, to be certified to operate or maintain robots a technician would need to pass a test associated with that class or level of robots. This would be much the same as a mechanic's or pilot's license. Such standards would force vendors to develop courses and materials according to an explicit level of quality.

Policy Options:

7. Work with professional organizations, unions or state agencies to develop voluntary competency standards for computer, robotic, and telecommunications technicians.

8. Establish legislation that requires government agencies to certify computer, robotic and telecommunications technicians.

9. Create federal standards for computer, robotics, and telecommunications technicians employed by government agencies.

Professional retraining is largely addressed by attendance at meetings and workshops under the auspices of professional organizations, a system which works but produces inequities in who gets retrained. Better methods of disseminating the proceedings of such meetings are needed. Video and computer conferencing technologies could ultimately alleviate geographical obstacles but further development of the technology is needed in terms of cost and usability. This an area that needs more private and public funded R&D.

Policy Options:

10. Provide R&D funds through an appropriate agency such as NSF, OSHA or NIH for projects that demonstrate the successful use of conferencing technology in professional and technical education.

11. Direct government labs to work with professional organizations to explore more effective means of disseminating their activities and results.

12. Require that a certain percentage of government travel budgets for professional activities be spent on alternative approaches involving conferencing technology.

There is one group of workers that is not covered by the preceding discussions: employees who experience deskilling as a result of technology and who are unable or unwilling because of literacy or motivational problems to participate in formal retraining programs. In many cases, such employees will be minorities, economically disadvantaged, or older workers. These individuals need special counseling attention to direct them to literacy programs, financial support, or retirement programs that best match their needs. Such counseling services are provided on a piecemeal and ad-hoc basis by state/local agencies, unions, and companies. There is a need for a more structured and better funded nation-wide counseling program. The development and coordination of such a program is an area needing federal resources.

Policy Options:

13. Legislation should require that every organization provide each employee with a certain minimum amount of career counseling on an annual basis or in the event of a layoff/termination.

14. A nation-wide vocational information database should be established and maintained by the Dept. of Labor.

15. A federal clearinghouse for information on literacy programs is needed.

There are a number of additional recommendations that go beyond the scope of this report but are closely related to retraining issues. Unemployment insurance is an obvious source of subsidy for workers undergoing retraining -- however, benefits do not last long enough to cover a worker through most retraining programs. Some states such as California have supplemental insurance programs that extend benefits for individuals engaged in full time retraining. A rethinking of the nature and implementation of unemployment insurance programs is required to facilitate retraining on a large scale.

In conducting this study, it was noted that there is no entity within the Department of Labor specifically concerned with retraining policy or issues. In fact the only agency explicitly tasked to address retraining is the Department of Education, Office of Vocational and Adult Education. There needs to be a closer and more direct liaison between the Department of Labor and the Department of Education in this regard. A coordinated policy that links educational availability and workforce productivity is needed if appropriate retraining programs are to be implemented.

Lastly, there is a paucity of data on the nature and effectiveness of retraining programs. The information that is available generally reports the success rates in terms of job placements (e.g., Somers, 1968). There is very little description of what retraining strategies work or how retraining is actually accomplished. In order to formulate detailed recommendations about how to implement retraining programs, such qualitative data is needed. A series of case studies or a comprehensive survey that examines success factors in retraining programs would provide the basis for more cogent analysis of retraining problems and solutions.

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