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ABSTRACT

Technology is having a definite impact on the workplace. Although workers in the fields of health care, administration, manufacturing, and electronics are all expected to exhibit industry-specific competencies, they must also master a similar set of technology-related competencies. This is especially true with respect to using technology to communicate with others and gather and use data. Technology affects workers differently. By reducing the time needed to compile and manage large quantities of data, technology has given some workers more time for creative, higher-level work that depends on the quick availability and easy manipulation of information. Other workers, however, are finding that increased technology may actually "deskill" or reduce the scope of their professional roles. For most workers, technology has become a mediator between workers and some facets of their job. Workers who know relatively little about technology, hold negative attitudes toward computers, or have a difficult time learning or upgrading technology skills may find themselves on the lower end of a professional hierarchy. Technology-rich workplaces demand continuous learning. Affective responses to technology also influence workers learning and productivity. Employers will likely be best served by helping experienced workers apply their current expertise to emerging technologies. (Contains 24 references.) (MN)

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TECHNICAL REPORT

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(March 1998)

National Center on Adult Literacy
Graduate School of Education
University of Pennsylvania

Consortium for Advanced Education
and Training Technologies
The Franklin Institution

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Technology in the Workplace:
Issues of Workers' Skills

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Abstract

This report examines the growing need for workers to expand their professional repertoire to include technology skills in the workplace and discusses basic skills demanded by most jobs. The guide begins by documenting the skills, competencies, and dynamics of individual industries or professions, and subsequently discusses the impact of new technology on workers' traditional activities. This is followed by a discussion of the workers' need to anticipate and be able to cope with rapidly changing technologies and examines a number of affective responses to these changes. The conclusion examines the benefits of helping experienced workers develop the new skills they need to keep up with changing technologies.

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EXECUTIVE SUMMARY

In recent years, there has been a movement toward defining and promoting professional technology competency standards. Many technology-related competencies that employers expect their workers to exhibit are similar across industries, particularly in the use of technology to communicate with others and to gather data. Additional competencies specific to particular industries are also required for many workers.

The movement toward defining standards is a reaction to the impact of new technology on workers' traditional activities. The presence of technology in work settings has enriched and expanded some workers' responsibilities. Since less time is needed to compile and manage large quantities of data, more time is available for creative, higher level work that depends on the quick availability and easy manipulation of information. Other workers, however, find that increased technology may actually "deskill" or reduce the scope of their professional roles. As procedures are standardized, workers' discretion, autonomy, and range of activities may be curtailed.

Generally, for most workers, technology has become a mediator between the worker and some facets of his or her job. As a result of this, many activities and much learning within the workplace have become removed from the objects of work, whether a machine part, raw data, or communication. This shift reduces workers' traditional reliance on sensory perception and requires that they rely on symbolic representations for the acquisition of skills and performance of workplace tasks.

Workers who know relatively little about technology, who carry with them negative attitudes and anxieties toward computers, or who have a difficult time learning to use technology or upgrading existing technology skills may find themselves on the lower end of a professional hierarchy.

A technology-rich workplace demands continuous learning, which will require both employees and employers to alter their expectations. In their efforts to keep abreast of the global economy, many employers are emphasizing professional flexibility in the workplace. Industries and organizations want their technologies and workers to be superior and operate efficiently; employees must be as skilled as the technology demands and dictates. Since both employers and employees benefit from the expansion of employees' skill sets, opportunities for employees to acquire and upgrade skills should be the responsibility of both partners. In short, employees should expect to learn how to use symbolic representations and employers should expect to invest more in continuous training.

Affective responses to technology also influence workers' learning and productivity. Technophobia among employees is a threat to productivity; however, it can be treated and reduced if an effort is put forth by employers. Ultimately, replacing experienced employees with less experienced workers (who possess specific technology skills) may not be a good investment in the long run. Employers would be better served by helping experienced workers apply their current expertise to the emerging technologies. ■

INTRODUCTION

Technology is pervasive in most professional environments. The presence of technology in traditionally "non-technical" workplaces creates a demand for differently skilled workers; this phenomenon is occurring across occupations and industries and produces similar needs and patterns across previously distinct work settings. In general, employees must expand their professional repertoire to include technology skills. The prevalence of computer-based technology requires workers to learn and apply new techniques and procedures for completing tasks and may ultimately cause certain employees to adopt different roles within organizations. As technology has prompted significant reorganization in and of work settings, employees have needed to develop a more complete understanding of their workplace as well as their contribution and place within it.

Defining the basic technology skills required in the workplace (or the creation of "standards") has become a crucial component of many industries' work plans. Clarifying expectations regarding individuals' professional competencies supports realistic decision-making on productivity issues. As suggested in *Raising the Standard: Electronics Technician Skills for Today and Tomorrow* (Electronic Industries Association & Electronic Industries Foundation, 1994), the conceptualization and development of technology skills standards (either across professions or within a particular profession) are especially important as companies' ability to facilitate and integrate technology into their general operations affects the United States' overall economic stability in a competitive global market.

The Secretary of Labor's Commission on Achieving Necessary Skills (SCANS) set out to define general workplace skills (1991). Although different professions clearly require the mastery of different and specific skills, most jobs demand a set of basic competencies. SCANS researchers interviewed employers, trainers, and workers from several industries in their efforts to define these generic skills. They identified two categories: foundation skills and workplace competencies. *Foundation skills* refer to employees' educational preparation, thinking strategies, and personal qualities. *Workplace competencies* refer to employees' practical and/or vocational skills. SCANS researchers further divided workplace competencies into the following five groups (p. vii):

- Resources—allocating time, money, materials, space, and staff;
- Interpersonal Skills—working on teams, teaching others, serving customers, leading, negotiating, and working well with people from culturally diverse backgrounds;
- Information—acquiring and evaluating data, organizing and maintaining files, interpreting and communicating, and using computers to process information;
- Systems—understanding social, organizational, and technological systems, monitoring and correcting performance, and designing or improving systems; and
- Technology—selecting equipment and tools, applying technology to specific tasks, and maintaining and troubleshooting technologies.

Although technology was identified as a separate category in the framework, in reality, technological competency permeates all of the above areas. Managing resources, communicating with colleagues, and acquiring, managing, and using information are enhanced by, and increasingly require, the use of technology. Workers must be familiar with many different kinds of hardware and software designed for different purposes; generally, they will be more productive if they feel comfortable working with technology and implementing various technology-based procedures.

SCANS found that most organizations currently expect their workers to possess high-level foundation skills and workplace competencies as prerequisites to new skill acquisition. Perhaps the most important overall skill is the ability to learn on the job, to recognize and adapt to change in the

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workplace. This ability is particularly crucial because the technology, itself, is constantly evolving. SCANS suggests that employees must continually build on their foundation of knowledge as they adjust to technology's evolution, learn about new products such as word processing programs, spreadsheets, databases, statistical software, and graphic software, as well as understand these programs' effects on their work environment.

While broad-based documents such as the SCANS report point to the complexity of the activities that people encounter in workplaces, they are not particularly informative about the skills, competencies, and dynamics of individual industries or professions. In this paper, we focus on the issue of technological competency within a select set of industries and examine the impact of technology on individual workers' roles, their work activities, and their acquisition of technology skills. This paper is not exhaustive in its scope; rather, it examines a number of critical issues affecting workers and their employers.

PROFESSIONAL TECHNOLOGY COMPETENCY STANDARDS

Following the publication of the SCANS report, many industries and researchers began to formally identify the set of competencies required of industry workers and disseminate this information widely. Competencies are typically identified in a variety of areas including reading, writing, mathematics, communication activities, technical expertise, and technology. As examples, the required technology competencies for four distinct professional fields (health care, administrative/secretarial, general manufacturing, and electronics) are summarized in this section, using the terminology of their own industry-specific standards reports when available. There are some similarities in skill requirements across the industries as technology is used for universal activities and there are also expected differences that reflect industry-specific activities.

Health Care

Far West Laboratory for Educational Research and Development, the National Consortium of Health Science and Technology Education, and the Service Employees International Union examined health care standards and identified the requisite skills for health care professionals in *Quality and Excellence: Health Care Skill Standards* (1996). Two functions of technology were identified: to improve overall health care management (insurance and patient record keeping, for example), and to advance specific client treatment and care. Specific technological competencies mentioned in this report indicate that employees may be expected to (a) understand the general flow of electronic information in the health care system and be able to enter and retrieve data on the computer, (b) use automated systems, (c) keep records of inventory and supplies, (d) communicate with co-workers through electronic mail, (e) monitor and evaluate patients' status, (f) interpret medical charts and other printouts, and (g) select and operate appropriate instruments and equipment in medical procedures.

Administrative/Secretarial

The presence and growing predominance of technology in offices and administrative settings has affected "secretarial" positions and requires this working population to maintain extensive technical skills. In *The Learning Industry: Education for Adult Workers* (1990), Eurich discusses some of the technical skills required of secretaries in government offices. Specific technology training courses are common in this setting; employees are encouraged to keep up with changing technologies. For example, first level secretaries in the Central Intelligence Agency must be able to type, understand small computer systems, communicate with co-workers and clients electronically, retrieve and transmit data, and use software packages for word processing, database management, and accounting.

General Manufacturing

In the manufacturing industry, computer-integrated manufacturing as well as automated manufacturing technologies are increasingly common. The National Coalition for Advanced Manufacturing (NACFAM) and the Foundation for Industrial Modernization (FIM) developed a set of skill standards for their industry. According to their report, *National Skills Standards Project for Advanced High Performance Manufacturing* (1997), workers should be able to identify possible computer applications in the manufacturing process. Some workers will also need to know how to (a) use industry-accepted software packages including word processing, spreadsheets, databases, statistical processing, and graphic software; (b) interpret and/or create computer-generated tables, graphs, charts, and blueprints (understand dimensions, symbols, abbreviations, etc.); (c) communicate with co-workers and customers via electronic mail (and other electronic modes); and (d) use an electronic calculator to work through job-specific mathematical functions.

Electronics

The Electronic Industries Foundation and its parent organization, the Electronics Industries Association, identified minimum standards for electronics technicians in their report, *Raising the Standard: Electronics Technician Skills for Today and Tomorrow* (1994), and in the accompanying document defining assessment criteria, *Characteristics of Competency: Measurement Criteria for Entry-Level Electronics Technician Skills* (1995). They determined that, at minimum, workers must be able to (a) type at a rate of 20 wpm (with 5 errors maximum); (b) enter data and control computer functions; (c) explain the difference between keyboarding and other methods of data entry; (d) use standard software applications for word processing (editing); (e) manage databases (be able to enter information into established databases and retrieve records); (f) create spreadsheets to record information; (g) interpret computer-generated tables, charts, maps, diagrams, and statistical information; (h) reproduce an electronic circuit using a sketching program; (i) communicate with co-workers electronically; and (j) access remote networks.

Electronics technicians should also understand microcomputer operating systems, microcomputer parts, and peripherals. They must be able to configure and maintain microcomputers using available operating systems and software packages, store and retrieve information, as well as troubleshoot and replace microcomputer peripherals (analyze interfaces to find problems and repair circuits). The technicians should know how the machines and information-sharing systems connect. Finally, they must maintain up-to-date technological skills (related to the electronics field) through inservice or external classwork, acquaint themselves with publications that provide technical information, and join electronic associations and attend meetings.

Technology Competency Commonalities Across Industries

It is apparent that some of the same technology competencies appear across professions. The industry standards summarized above suggest that technological communication skills are paramount across professional settings. Workers must know how to use technology to communicate with customers and co-workers. Interpersonal exchanges frequently occur via e-mail; workers must learn how to pose questions, offer criticism, relay information, and so forth through this medium. If workers are not able to use e-mail (and/or other electronic forms of communication such as videoconferencing or collaboration technologies), they lose a crucial opportunity to express themselves and may find that more technologically proficient co-workers are in a position to promote their own viewpoints and gain influence.

In addition, many industries expect workers to maintain a general understanding of computer functions that support the collection and aggregation of information, whether it be for record keeping, monitoring, inventory, or quality control. Software programs most often mentioned as crucial components of workers' technological skills include word processing packages, spreadsheets, and databases.

THE IMPACT OF NEW TECHNOLOGY ON WORKERS' TRADITIONAL SKILLS

As exemplified by the industry standards summarized above, many industries have incorporated technology into all aspects of operations. Competencies such as those identified above now define employees' activities, and thus what has traditionally been done and valued by workers in the workplace may be changing. Researchers' attempts to measure these changes and generalize from the data are limited by the variety of contexts in which work is done (Cappelli, 1992). Yet clearly, in some industries, in some work environments, and for some people, that which was previously valued is no longer useful. For other people, technology has presented opportunities or demanded the expansion of roles within existing jobs. For a third group, technology has simply enabled people to do their jobs more efficiently. Here we will describe a number of workplace situations that capture aspects of the impact of technology implementation on workers' skills, with no claims of generalizability across settings. But before examining technology's effect on traditional skills, a working definition of the term *skill* must be established.

The word *skill* is sometimes used to denote a specific competency, such as *keyboarding skill, measuring skill,* or *interpersonal skill.* However, for a discussion of the impact of technology on workers in the workplace, it is more appropriate to define *skill* broadly, encompassing not only specific activities and knowledge, but also the roles, responsibilities, and levels of autonomy that contribute to participation in a work environment. The definition of *skill* as formal knowledge and personal attributes (such as could be credentialed) or as the competency to fulfill a particular sequence of job-related performance tasks, distances the term from the actual on-the-job experience (Scarselletta, 1993). Rolfe (1990) suggests a useful model of *skill* that captures some of the richness of what it means to participate in the workplace. Her model combines two dimensions—technical complexity and discretion.

Technical complexity encompasses three component factors: the complexity of tasks, the required knowledge, and the range and variety of tasks. The *complexity of tasks* depends on whether simple or complex procedures need to be followed, the number of steps required, and the complexity of tools used (i.e., physical tools for manual tasks, sources consulted and text/numerical manipulation tools for non-manual tasks). In addition, tasks are considered more complex if consequences for errors are serious. *Knowledge* areas include the workings and capabilities of equipment, processes, and integration of tasks. The *range and variety of tasks* reflect the breadth of discrete tasks but also the depth of work within narrow tasks.

Rolfe's second dimension, *discretion,* also encompasses three component factors: (a) *decision-making power,* the use of knowledge, experience, or intuition to decide between competing demands such as quality versus productivity; (b) *control over the organization of work,* referring to autonomy over the ordering and performance of tasks; and (c) *supervision,* the amount of control over the work of others.

Deskilling Following Implementation of Technology

The reduction of one's technical complexity and discretion can be termed "deskilling." In workplace environments, the introduction of technology has produced a deskilling effect on certain employees while others' skills have been enhanced. Research on the skilling/deskilling of machinists, clerical workers, and retail merchandisers demonstrates that changing technologies can have very different effects on different people in different professions. This research is ethnographic in nature and is based on observations of and interviews with individuals in their work environments. Some of this research is summarized below, with particular emphasis on machine workers since their experience on the job seems to have undergone quite radical changes.

Bohle, Milkau, and Rose (1992) explain that skilled machine workers at conventional machines depend on a variety of sensory perceptions to inform their manual movements. They check and identify defects and irregularities by using the sounds of the machine as a guide; they develop a tactile sense of how processes feel; they interpret what they see in tools' wear and tear. Workers explain that they do not work "on" their machine but rather "with" their machine as a manual tool. "As one skilled worker expressed it: 'With the knob in your hand, you have the machine under control. I can feel what I'm doing in my hands'" (p. 110). This sense of "feeling" goes beyond the tactile, to developed intuitive perception, judgment, and confidence, "Everyone sees things differently and if someone doesn't have a feel for it, then he simply can't see it; it's a matter of feeling" (p. 111). Bohle, Milkau, and Rose conclude:

> Our empirical findings suggest that such ways of working are far more than a preliminary stage on the way towards scientific analytical thinking, or indeed, basically inferiour to such thinking. They tend, rather, to be an independent and—in this sense—qualitatively different form of 'grasping' reality which is needed to complement the technical, scientific way of getting to the bottom of the production process. (p. 111)

The advent of Computerized Numerical Control (CNC) machines has resulted in changes in the ways that machinists work. Workers perceive that the possibility of regulating machining operations directly is limited, "It used to be possible to watch and make decisions during the machining operation with the intention of delaying tool wear by lowering the cutting rate. You can't do this any more. You have to decide and plan everything in advance. Direct reactions to changes in the work process are impossible. The most you can do is switch off prematurely" (Bohle, Milkau, & Rose, 1992, p. 114). Skilled machinists are still expected to correct malfunctions and monitor and inspect the performance of machining operations. Good CNC programs may not run effectively if the particulars of the machine and material are not adequately taken into account or are difficult to establish in advance.

However, the use of the workers' own sensory perceptions is constrained by the encasement of machines, which limits the workers' access to sound, feel, and the ability to see parts from different vantage points. One worker stated, "In the long run, CNC-workers are losing their skills by working on machining centres. They no longer come into contact with the workpieces in these situations. Part of the worker's skill, namely his sense of precision, is vanishing" (p. 115). Skilled machinists who have begun working with CNC machines may feel a loss of control over the equipment as well as increased pressure due to the high costs of the machine, frequent downtimes, and defective piece production.

Thus, skilled machinists who are now working with CNC equipment may believe that the technical complexity of their jobs has been reduced. While use of the CNC machines requires additional learning to understand the workings and capabilities of the equipment, the accompanying reduction in the number of hands-on activities, available sensory data, and the variety of tasks encountered may result in a perceived net loss. More fundamentally different, however, is the level of discretion that the machinist feels. There is less immediate decision-making power; the ability to make continuous adjustments during the machining process has been curtailed and feelings of personal control over the process is reduced. Autonomy has been lessened.

Another, perhaps more familiar example of the deskilling impact of introducing technology into the workplace is that of the clerical insurance underwriter (Rolfe, 1990). Traditionally, client and insurance information was manually recorded in paper files, stored, and then retrieved by underwriters when updating policies or responding to inquiries. Underwriters also calculated insurance premiums and generally specialized in either commercial or personal insurance since policies in the two areas were typically quite different from each other.

The form of the underwriters' functions changed significantly with the implementation of computer technology. Underwriters started entering all information into one database that could be accessed, updated, and consulted easily. While this simplified procedures, it also reduced the technical complexity of the underwriters' position by limiting the range of tasks. Even though computer skills were required, the use of formalized data entry templates allowed the underwriter almost no opportunity for manipulation, flexibility, or creativity. Furthermore, since new technology reduced the possibility of errors and uncertainty, few decisions needed to be made and little opportunity for discretion remained. Computerization encouraged insurance companies to move from tailor-made to standardized policies, further reducing the value of underwriters' specialized knowledge, their task range, and their discretion.

The concept of *deskilling* reflects the change process as technology is integrated into a work environment. The technical complexity required and an individual employee's levels of discretion change as tasks that had been completed by men and women are completed by computers or in conjunction with computers. From the two examples above, it is apparent that these changes can be significant and may well cause feelings of frustration and demoralization for those workers who previously felt satisfaction and pride in their skilled work.

Skills Increase Following Implementation of Technology

While deskilling occurs for some people when technology is introduced into a work environment, for others, technology allows the job description to expand beyond the original duties. The expansion may be into areas that previously were under another job description (actually combining jobs) or may be into areas that previously were nonexistent. The complexity of work is expanded and discretion may be enhanced if autonomy is increased.

Nelsen's 1991 study (cited by Barley, 1992) of secretaries working in universities suggests that the prevalence of personal computers among faculty has changed the secretaries' responsibilities. Professors are now better able to attend to many of their own professional needs such as correspondence, typing papers, and other paperwork, thereby relieving administrative personnel of these responsibilities and enabling them to pursue other activities. In these settings, secretaries now assume more of the responsibilities typically assigned to research assistants. Similarly, Zuboff's (1989) study of computer-integrated paper mills indicates that the presence of technology requires blue collar workers (who have traditionally had limited discretionary responsibility) to analyze data and make decisions based on their analyses.

Scarselletta (1993) describes a hematology laboratory in which technicians use sophisticated machines to analyze blood samples. Activities are routine until a machine malfunctions. Then, blood analyses have to be done manually, a task that technicians are capable of completing but which they would prefer not to do because time constraints and fear of committing errors greatly add to the pressures that the technicians already feel. Thus, everyone wants the machines to be repaired as soon as possible. All the technicians in the laboratory have received extensive training in hematology analysis procedures but have not received training in repairing machines; however, Tom, one of the technicians, has become adept at troubleshooting the machines. He has developed his expertise informally, without classes, training, or texts. He finds the error codes produced by the machines to be meaningless and does not rely on the technical manuals available in the lab. Tom has developed

> ... "my own material," which turned out to be a worn, thick red binder in which he ha(d) accumulated hundreds of technical documents, (and) jotted notes and observations

> pertaining to all aspects of laboratory machine operation. He said it ha(d) taken him several years to collect these documents. (p. 11)

Scarselletta reports that Tom's troubleshooting abilities are highly valued by the other technicians; his skills enhance his standing within the group. While earlier hematology laboratory technicians had done analyses by hand, the technicians in this lab appreciate the technology as a tool and are reluctant to give it up. This technician has expanded the technical complexity of his job to include troubleshooting and repair of the laboratory machinery, taking advantage of the technology to widen his expertise and scope of work.

Enhanced Performance Following Implementation of Technology

In some jobs, technology aids in the efficient completion of routine tasks so more time is available for the higher order activities that are the essence of the job. A study of retail merchandisers (Rolfe, 1990) showed that the implementation of technology was considered a positive development that enhanced work-related skills. Retail merchandisers are responsible for ordering goods for the stores under their aegis and making sure that the stores always have appropriate quantities of the inventory available for sale. They are part of the decision-making structure of their organizations and, therefore, have a high degree of discretion in their positions; they are valued as employees for their abilities to make judgments that reflect not only an analysis of data but also intuition and experience. The advent of computer technology meant that the merchandiser no longer had to calculate sales figures manually. Data could be manipulated easily and therefore, more time could be spent on the portions of the job that required the merchandisers' expertise and experience. While the range of tasks was reduced (less manual data manipulation), the complexity of the tasks was increased in that more sophisticated sales models could be developed and analyzed. These people already were in positions of high discretion and since they controlled the use of technology in relation to their work tasks, discretion was not reduced.

USING TECHNOLOGY EFFECTIVELY REQUIRES "META-KNOWLEDGE"

While employees need to acquire specific technology skills such as the industry-identified competencies described earlier, the acquisition of such abilities may not be sufficient to ensure the effective use of the technology. Equally important is the overview or broad-based understanding of workplace goals, processes, and relationships that enables an employee to link technology to task and vice versa. The user of technology must identify appropriate technologies for a task at hand, monitor and reflect on the implementation, and make certain that the needs of the task are being met. This oversight function presupposes an understanding of what each technology application does, a recognition of the appropriate contexts in which alternative technologies can be applied, and an appreciation of the relative benefits and limitations of alternative technologies and applications. Furthermore, a sensitivity to the culture of a specific worksite and/or understanding of the specific industry's operations is necessary for meaningful implementation of technology as a communication and professional tool. Examples from the medical field, the banking industry, and the secretarial world followed by an examination of e-mail will develop these points.

Many industries integrated technology into their working activities a number of years ago. The employees that were hired well after the establishment of technology-rich procedures may feel comfortable with the technology but may not fully understand the activities that were replaced by the technology. This knowledge gap may be particularly apparent in situations when technology is used to store large data sets and/or execute complex mathematical operations on that data.

Medical profiles of patients are routinely developed from continuous recording of vital signs' data to help nursing staff monitor post-surgery recovery progress. In investment banks, financial instruments such as interest-bearing securities and discount "paper" have been developed using a variety of mathematical models and having distinct patterns of payments and potential risks. Formerly, these computerized functions, or more elementary forms of them, were performed by individuals who sometimes made calculation errors and who could handle only a limited quantity of data. Now, while the benefits of computer-generated, data-rich summary statistics and models are apparent, the processes by which the summary statistics and models were derived may no longer be transparent to those who make decisions or give advice based on them. For example, newly trained nurses working in hospital intensive care units are adept at monitoring patients and rely on the myriad of constantly updated vital sign summaries for information. More experienced nurses, however, who formerly spent much time measuring the vital signs of their patients, claim that sometimes the summary scores mask important vital sign fluctuations. They suggest that less experienced health care professionals may not understand the significance of the measurements that underlie the summary scores and may not sufficiently protect against errors in patient monitoring (personal communication).

Similarly, financial instruments and numerical indices used in the banking industry are based on mathematical models. Noss and Hoyles (1996) report that many employees use these tools without understanding the mathematics underlying the models and, therefore, without appreciating their limitations. For example, Noss and Hoyles asked bank employees in Britain to suppose someone started with 100 pounds, invested for one year at a fixed interest rate of 10%. If the choice of compounding frequency is open, what is the maximum that can be earned? The general response was, "It could be compounded almost continuously, i.e., many millions of times a year which would create huge returns" (p. 22). These employees may well advise customers to focus on the frequency of compounding periods rather than on other considerations such as interest rate or risk. (Actually, with continuous compounding over the one year, only 52 extra pence would be earned over and above the simple interest payment of 10 pounds.)

In many industries, computer-based analyses of market conditions, inventory patterns, and production runs are frequently used to inform purchasing or sales decisions. Again, dependence on technology has to be balanced with knowledge and experience. A scenario described by Noss and Hoyles (1996) demonstrates such a situation:

> Peter was in charge of support and maintenance of computer equipment .... One of his tasks was to assess the relative merits of buying or leasing equipment. Now, there is a futures market in IBM computers .... Peter could work out with some accuracy, the value of a piece of equipment at a point in time in the future. How did he do this? By entering various parameters on his spreadsheet (a spreadsheet whose model had been set up centrally) and using the PV function (PV stands for present-value; how much is something worth now if I know what it is worth in the future?). In short, explained Peter, "I press the button and see what it says."
>
> What then?
>
> "I look at the answer. If it seems to indicate what I think we should do, I use the number to justify my decision. If not, I ignore it, or put in figures which will support my hunch." (pp. 7-8)

Peter may indeed be an expert; he may understand the market well and may intuitively realize that the spreadsheet program is limited or inflexible. He believes his own judgments, based on years of experience, are more trustworthy and preferable to the unyielding spreadsheet program. However, Peter may not be as knowledgeable as he thinks he is; he may ignore the useful tool that should guide his decision. As the instrument is not transparent, Peter cannot see the mathematical model upon which the instrument is based.

Employers expect that technology will

facilitate decision-making processes by enabling employees to harness the power of large amounts of unwieldy data and "expertise" that went into the programming of computer applications. However, since the underlying information is hidden from the user, it is possible that expected outcomes are compromised. Additionally, the position of an employee within the decision-making process will determine whether he or she has the discretion to trust and use his or her existing expertise. The culture of a particular workplace will also determine whether employees will have the support and opportunity to develop their intuitive skills as well as their technical skills.

The culture of a particular workplace and workers' perceptions can also have an impact on whether or not technology is used in the workplace, and how that is accomplished. Electronic mail (e-mail) can be a very useful tool to facilitate communication within organizations. It is asynchronous, which means that the sender and recipient do not have to be available at the same time, geographical distances are irrelevant, and communication can be direct, without intermediaries. However, Golden, Beauclair, and Sussman (1992) suggest that a number of factors beyond the specific knowledge of how to use e-mail may have an effect on whether or not individuals choose to use it in a workplace. Perceptions of qualities of the media, managerial roles, as well as critical mass and social pressure were found to affect e-mail use.

Generally, users of e-mail perceive it as a "cool medium," one that is void of the nonverbal cues and nuances that enrich face-to-face communication. Thus, organizational members tend to use e-mail when it seems appropriate for particular tasks or when the sender wishes to protect himself from direct, face-to-face, threatening confrontations (Sherblom, 1988). Organizational members also see e-mail as a desirable tool to enable enhanced communication between departments (a liaison role) but of limited use to communicate within a department (dissemination role). Intradepartmental communication tends to occur easily through a variety of other, perhaps less formal, channels. Finally, the climate of the workplace has an impact on e-mail usage; both formal and informal pressure are positively associated with its usage.

Barnes and Greller (1994) considered the effects of e-mail on collaborative work efforts and organizational hierarchies, with particular attention to computer-mediated communication in cooperative work. They suggest that e-mail changes the nature of information exchange and communication both within and between organizations.

According to Barnes and Greller, the characteristics of e-mail as a mode of communication affect conditions in the workplace. Generally speaking, e-mail encourages communication in the workplace because it supports dialogue across organizational "levels." E-mail helps "lower level" workers contact "bosses" without having to deal with the usual "contact roadblocks" (e.g., secretaries). Thus, the presence of e-mail in an organizational hierarchy can support an open-door policy for all employees and the relative anonymity of e-mail may actually afford employees of all professional "levels" an equal opportunity to voice concerns and questions in a public forum.

In some work environments, e-mail can help coordinate work efforts in a way that affords subordinates more decision-making power. "Superiors" send messages that describe tasks; workers, in turn, follow the general directions given in these electronic messages (but they tend to do so with less direct supervision). Workers who receive work orders via e-mail require more extensive training and/or education prior to or early on in employment; it is clearly necessary for these workers to become acquainted with the technology in order to perform job functions.

Professionals who use e-mail may enjoy more flexibility in their jobs because communication with co-workers is not restricted to the physical office or typical office hours. E-mail can also save time within an organization because it eliminates the hassles associated with locating co-workers and convening meetings. Many users feel that it simplifies conferencing. Instead of struggling to establish convenient meeting times, administrators can distribute group messages that essentially convey the crucial information. Proceedings can be saved and copied for archives that are accessible to all involved. E-mail conferencing also tends to support ongoing discussions as employees can easily ask questions and post answers.

Finally, Barnes and Greller note that e-mail tends to shift workers' attention on the job; generally speaking, it requires a concentration shift from speech to text. Thus, employees using e-mail must be able to write concisely as well as interpret and respond to written messages, rather than rely solely on conversations to support and direct their work.

A TECHNOLOGY-RICH WORKPLACE REQUIRES CONTINUOUS LEARNING

In the past, workers acquired a set of skills that became their tools of the trade for their entire working lives. Once skills were in place, employees expected that they would be able to handle most tasks they would encounter and that the demands of their jobs would not change significantly over time. However, during the last 30 years, it has become apparent that workplace technology changes swiftly; new technologies are introduced and replaced frequently and computer applications are updated almost annually. Employees must now anticipate and be able to cope with the need to constantly upgrade their skills. Everyone can expect to be continuously learning, and perhaps never achieving a state of mastery.

One would hope that a worker's knowledge of one piece of technology or one software program would enable him or her to transition easily to a newer form of the same technology, an updated or upgraded form of the software program, or an equivalent software program that is being substituted. Thus far, we have found no research exploring the difficulties that workers encounter as they attempt to transfer their technology skills from one technology to another or from one software program to another. Research on the transfer of skills from school to work (e.g., Cognition and Technology Group at Vanderbilt, 1990; Morris & Rouse, 1985) or from work to school (e.g., Nunes, Schliemann, & Carraher, 1993), however, suggests that transfer between applications may require more than just knowing "how to do" a task. Workers need a deeper and broader knowledge; they must understand the "when" and "why," as well as possess an overview of the entire system rather than only a view of the narrow function within the system that the individual worker fills. Thus, the focus of technology training should not be limited to the mastery of isolated procedures but rather should help workers develop an understanding of what they are doing and why they are doing it. Training should help employees identify and become familiar with alternative procedures that yield the same results. When workers have this background knowledge, they are more likely to be able to be proactive in the identification of new applications or the improvement of existing procedures in the workplace.

In technology-rich environments, symbolic learning processes are replacing more traditional hands-on learning methods. Traditionally, individuals learned work-related skills in courses, during apprenticeships, or in informal ways such as shadowing a skilled technician to observe and ask questions. The machinery or equipment used was visible and touchable so learning, whether as a secretary, medical assistant, machinist, mechanic, or electrician, was observational and tactile.

With the advent of electronic processing and computerized manufacturing, workers must rely more on symbolic representations, whether verbal (for reading manuals), diagrammatic (for comprehending complex schematics), or mathematical (for programming machines or using statistical process control programs). The acquisition of workplace skills has correspondingly become a less visual and less hands-on process. The skilled hand and skilled eye have been replaced by symbolic commands (Berryman, 1993). For those whose "learning style" is more visual and concrete and who entered professions that relied on a "hands-on" relationship between worker and task, this shift leads to frustration and professional limitations.

AFFECTIVE RESPONSES TO TECHNOLOGY

While computers have become ubiquitous within almost all workplace environments, some people continue to feel anxious about them. Rosen, Sears, and Weil (1993) estimate that fully one fourth to one third of the general public can be classified as technophobic to some degree. Technophobia is of concern to employers because anxiety and negative attitudes can interfere with an employee's performance by extending the time needed to accomplish tasks or by contributing to the number of errors made. Technophobic individuals may exhibit nervousness, be tense and testy with co-workers, or may be hesitant to take on new tasks that require additional work with computers. All of these manifestations will disrupt the workplace environment and reduce the productivity of workers.

People who exhibit negative feelings toward computers often feel incompetent with respect to technology. While they may feel confident in other aspects of their lives or work, they suspect that computers require a kind of thinking or activity that they are unqualified or unprepared to perform. These people are the ones who tend to feel overwhelmed at having to continually deal with software upgrades or technology changes. Unfortunately, as with other anxieties, people who are anxious about computers find themselves in an ever worsening cycle of negative affective reactions. Computer anxiety leads to computer avoidance which, in turn, further contributes to the computer anxiety (Rosen, Sears, & Weil, 1993).

In a survey of employees in a real estate office, Murrell and Sprinkle (1993) found that 90% of the sample stated they think it is fair to be expected to learn new systems and 79% said they believe it is worthwhile to learn about computers and software, even though the technology is changing so quickly. However, 31% of the employees doubted their ability to use computers, 21% said they avoided using computers, and 38% had concerns about their ability to use computers efficiently. Computer avoidance and feelings of frustration and confusion were found to be associated with lower job satisfaction. This finding is of concern because low job satisfaction has been shown to be associated with high rates of absenteeism and job turnover (Porter & Steers, 1973).

In a meta-analysis of available research about computer anxiety, Rosen and Maguire (1990) concluded that "(a) computerphobia does exist, (b) women are not necessarily more computerphobic than men, (c) older people are not generally more computerphobic than younger people, (d) computerphobia is not simply an extension or manifestation of math anxiety, (e) computerphobics are not simply anxious people demonstrating their discomfort in a different arena, and (f) computer experience alone does not cure computerphobia" (cited by Rosen, Sears, & Weil, 1993, p. 28).

Given the prevalence of negative attitudes and negative feelings toward computers and the resulting negative implications for the workplace, businesses would do well to acknowledge the problem and help affected employees reduce their computer anxiety. Programs that include individualized assessment, systematic desensitization, thought-stopping/covert assertion training, and information/support (such as described in Rosen, Sears, & Weil, 1993) would be appropriate.

CONCLUSIONS

While the use of technology is clearly increasing in workplace settings, the impact of this change is not felt equally by all members of the workforce. In some settings, technology is gradually becoming integrated into ongoing activities so that workers have time to familiarize themselves with new technologies and have opportunities to learn new skills on the job. In other settings, technology implementation abruptly and radically changes workers' activities, with little warning or time for preparation. Workers' skills may no longer be useful and individuals may have difficulty making quick transitions into technologically rich activities. Many employers choose to replace "obsolete," though experienced, workers with those who come to employment with technology skills already in place but not much industry-specific experience.

The value of experienced workers should not be underestimated. New workers with stronger specific technical skills lack the accumulated knowledge and "feel" of experienced workers—characteristics not so easily developed or trained. Perhaps, in the long run, it is beneficial to make a commitment to helping experienced workers develop the new skills they need to keep up with changing technologies. Such a program of support would include the development of good quality, accessible retraining that builds on the skills that had been previously valued and that recognizes and addresses affective issues such as computer anxiety and feelings of displacement that may be barriers to progress.

Those entering the workforce will be expected to bring knowledge of and experience with general communication and data-related technologies as well as those technology skills appropriate for a particular work setting. To ensure that individuals are indeed prepared technologically for the workplace, it is the responsibility of industries to clarify expectations and inform potential employees, educational institutions, and vocational training organizations of skill requirements. Pre-employment assessments should also target those skills that are actually required for successful employment.

In an increasingly technological world, the expansion of American workers' skills to include technology depends on a commitment from all parties, including the workers themselves, industries and workplaces, and educational and training institutions. While all may not celebrate changes due to technology, a national environment that expects and supports continuous learning and growth can help ease these transitions. ■

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