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ABSTRACT

Directed to individuals responsible for program planning in vocational education at the national and state levels, this review and synthesis of technological developments in robotics and office automation identifies the potential demand for skills in these technologies in the next 3 to 5 years. The procedures for the study are described in the first chapter. Chapter 2, on robotics, begins with a definition. A discussion of usage patterns includes information on influences on usage (price of labor versus capital investment, cost, interface, assembly) and projections of usage. A section on training implications for vocational education offers information on skills and training requirements and suggests that a significant demand for newly trained robotics technicians will not develop. Chapter 3 on office automation begins with a definition and then discusses the use of technology and influences on the office automation equipment. A section on training implications for vocational education at the secondary and postsecondary levels discusses the need for word processing training for entry-level personnel and retraining needs for the acquisition of higher-order skills in analysis, comprehension, and logical thinking. (YLB)

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ROBOTICS AND OFFICE AUTOMATION:
IMPLICATIONS FOR VOCATIONAL EDUCATION

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FOREWORD

The pace of change in information, communications, and control technologies has produced a heightened awareness throughout society of the potential impact of these technologies on all aspects of our lives. Probably the major concern is that automation, particularly automated manufacturing, may cause massive unemployment. There seems to be less concern about office automation, but the changes in this setting may be even more far-reaching than in the factory.

Obviously, if vocational education is to prepare people properly for the work force of the future, vocational educators must understand the nature of current changes and anticipate possible (as well as probable) future developments. The information assembled and presented in this report represents one effort of the National Center to help vocational educators anticipate and plan for a changing world.

This project was conducted in the Information Systems Division under the direction of Joel Magisos with funding from the Office of Vocational and Adult Education, U.S. Department of Education. The project staff included the authors of this report; Judy Samuelson; Jay Smink, Project Director; and, for part of the project, Mollie Orth. Sherri Trayser served as project secretary and word processor for this report. National Center staff members, Gale Zahniser and Joel Magisos conducted internal reviews of the report, and Constance Faddis provided the editorial review.

The project and report also benefited from the participation of several others who are not on the National Center staff. These include the following individuals, who participated in small convenings conducted at the National Center: Lloyd Carrico, Industrial Robot Division, Cincinnati Milacron; Walter Cwycyshyn, Robotics Division, General Motors Technical Center; Timothy Hunt, W.E. Upjohn Institute for Employment Research; Ruth Nelson and Martin Smith, Product Line Evaluation and International Forecasting Business Plan Division of International Business Machines; Connie Taylor, Nationwide Insurance; and Jeanne Woldenberg, Association of Information System Professionals. Joseph F. Coates, Joseph F. Coates, Inc., and Robert C. Harris, Indiana University provided external reviews of the report.

On behalf of the National Center, I wish to express our appreciation to all these individuals for their interest and involvement. Naturally, the positions presented in this report may not reflect the views of any of these individuals, other than those of the authors themselves.

Robert E. Taylor
Executive Director
The National Center for Research
in Vocational Education

EXECUTIVE SUMMARY

Under its contract with the Office of Vocational and Adult Education, U.S. Department of Education, the National Center conducts "yearly studies of selected occupational areas, with an emphasis on ones requiring a high degree of technical training in high demand occupations."* The purpose of the yearly studies is to determine the need for special packages of information and products for users that can then be prepared and disseminated. This report is directed to individuals responsible for program planning in vocational education at the national and state level. This review and synthesis of technological developments in robotics and office automation identifies the potential demand for skills that will be required to respond to these technologies in the next three to five years.

The applications of microelectronics technology to a variety of information, communication, and control equipment are causing many changes in the nature of work in the factory and the office. It is in these settings that the vast majority of the American work force is employed. The potential scope of these changes and the wide attention they have received led to their selection for an examination of the implications of developments within these technologies for training within vocational education.

As information on these topics was assembled, it took two opposite directions. The information on automated manufacturing tended to focus on robotics. The information on office automation, in contrast, spread from an initial concern with word processing to the broader topic of information and communication technology in the office.

For both of these areas, the general research procedure consisted of assembling all relevant information that could be identified and integrated, and supplementing this information with input from knowledgeable individuals. A special effort was made to identify any indicators of future directions, such as sales projections or technical innovations. Information in the two areas was assembled and summarized. Selected industry representatives were brought together to review the material. These representatives were asked to assess the accuracy and comprehensiveness of the material and to help project staff assess implications for vocational education.

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*Request for Proposal Number 82-028, U.S. Department of Education, 26 May 1982, p. 7.

The following implications were drawn from the assembled information on robotics and office automation.

There were about five thousand to seven thousand robots in use in the United States in 1982. Growth in the industry is expected to average about 35 percent per year, resulting in fifty thousand to one hundred thousand robots in use in the United States by 1990. The adoption of robots is causing a skill shift in manufacturing by displacing low-skilled operatives and assemblers and requiring higher-skilled technicians to maintain and repair the robots. Major unemployment as a result of this displacement is not likely. Although there will probably be some unemployment, especially in geographic locations heavily dominated by metal-working industries, many displaced workers will be transferred and retrained by their employers.

In the next three to five years there is not expected to be a significant demand for newly trained robotics technicians. Most technicians now working on robots obtain their training from the manufacturers of the robots. For the most part, these technicians are industrial machine mechanics and electricians already employed by the firms that purchase the robots. The automobile industry will continue to be the largest user of robots in America for the next three to five years. The need for technicians in this industry will be filled primarily by the recall and retraining of laid-off electricians and machine mechanics.

Information handling and communication processes in the office will change dramatically in the next three to five years. Computer literacy, an understanding of the fundamentals of electronic storage and retrieval, will be essential for all office workers. Word processors, in the form of stand-alone stations or integrated networks, will gradually continue to replace typewriters. Personal computers will function both as word processors and as stations for information retrieval, analysis, and transmission. Keyboard skills will continue to be essential. Computers that will respond to voice command are not likely to be commercially feasible in the next three to five years.

An instructional unit on word processing should be included in every basic typing course. Office workers should understand the basic principles of office automation and how the various components interface to form a system. Managers currently lacking these skills and understanding represent a large potential market for continuing and adult education programs.

CHAPTER 1

INTRODUCTION

Technological advancements are having an impact on the nature of work in our society. As such, it is important for vocational education to anticipate the implications of these advancements on skills training to be demanded in the future. Under its contract with the Office of Vocational and Adult Education, U.S. Department of Education, the National Center conducts "yearly studies of selected occupational areas, with an emphasis on ones requiring a high degree of technical training in high demand occupations."* The purpose of the yearly studies is to determine the need for special packages of information and products for users that can then be assembled and disseminated. This report is directed to individuals responsible for program planning in vocational education at the national and state level. This review and synthesis of technological developments in robotics and office automation identifies the potential demand for skills that will be required to respond to these technologies in the next three to five years.

This report examines two pervasive technologies: automation in the factory (as reflected by the installation of robots) and automation in the office. Each of these applications of microprocessor technology are changing the nature of work. As the nature of work changes, the nature of the preparation required for that work also changes. By examining projected adoption patterns of these technologies and the skills required to work with them, the report will identify both the demand for skills and the need for skills training in these areas.

The report addresses the need of vocational educators who are trying to decide whether or not to implement a program in robotics or office automation. It is not designed for the developer of specific curricula. Ashley et al. (1983) have proposed guidelines and specifications for the content of robotics training curricula. This current report does not attempt to duplicate those efforts. Rather, it responds to the question, "What will be the demand for new skills training caused by the application of microprocessor technology in the office and the factory?"

Selection of Technologies for Study

A number of commercial products and processes derived from new technologies are gaining widespread adoption in the economy.

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*Request for Proposal Number 82-028, U.S. Department of Education, 26 May 1982, p. 7.

For example, lasers, fiber optics, and microprocessors are three pervasive new technologies. Since only two application areas of technologies were to be studied this year, the following criteria were developed to select the areas of study:

- o The occupations affected by these technologies must require a high level of technical training.
- o There must appear to be a potential for high deman for individuals trained in this area.*
- o Training must be provided below the baccalaureate level.
- o The impact of this technology must be felt within three to five years.
- o Preference should be given to discrete technologies: those where the impact can be identified separately from other improvements in processes and products.

Early in the project, staff collected information from diverse sources about the impact of technologies in the near future. Some technologies, such as biotechnologies, were discounted because the impact of that technology will not be felt for several years until more products are commercially feasible. Lasers and fiber optics tend to be integrated with other technologies and are generally applied to enhance one specific process in a series of processes in their application. Microprocessor technology is clearly the most discrete technology and the most pervasive in its applications. Thus, since the impact of the microprocessor can be linked to different sectors of the economy, two such areas were selected for study: the office and the factory.

Microprocessor technology in the office and in the factory automates work, which increases productivity. Office automation is a generic term that identifies a variety of equipment that, when linked together, improves communication capabilities and the accuracy, ease, and availability of information. Factory automation includes a number of automated activities in the production process, including computer-aided design and computer-aided manufacturing (CAD/CAM), automated materials handling, automated storage and retrieval, and robotics. Althouth the entire range

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*Heightened awareness and a proliferation of robotics programs served as an indication that there appeared to be a potential high demand for robotics technicians. However, it is unlikely that a high demand for individuals trained in this area will materialize in the next three to five years.

of automated applications in the office are discussed in this report, the discussion of automation in the factory is limited to the impact of robotics.

Procedures

Once the areas of office automation and robotics were selected for study, project staff (1) assembled information describing each technology, its current usage patterns, projections of usage for the remainder of this decade; (2) identified skills required to use these technologies; and (3) identified the demand for these skills in the next three to five years. Implications for vocational education were then identified. Information was assembled and a packet of background materials was prepared.

To validate the completeness and the accuracy of the information assembled, industry representatives were convened in two separate meetings. The convening on robotics included a representative from a robot manufacturer, a representative from a user firm, and a scholar in the study of the impact of robotics on human resources. The convening on office automation included two representatives from a major manufacturer of office equipment, one representative from a user firm, and a representative from a trade association. A listing of the convening participants and their affiliations appears in the appendix.

Convening participants were asked to respond to the accuracy of the materials presented and to identify any gaps in the information base assembled. Participants also assisted in the development of the implications of these findings for vocational education. Specifically, they aided in identifying the skills requirements for the individuals using these technologies and in identifying future roles for vocational education.

Transcripts of the convenings were produced, and the information obtained is synthesized in this report. Project staff also further investigated new information provided by convening participants. Published sources were identified to verify the conclusions drawn from the convenings.

The findings from this report will be used as background materials for a National Center project to be conducted in 1984-1985. One of the areas investigated here will be selected for the identification of curriculum materials. Curricula already developed by vocational education institutions will be assembled for dissemination to other institutions that wish to develop or revise current curriculum offerings in the areas of these new and emerging technology application areas.

CHAPTER 2

ROBOTICS

The integration of traditional manufacturing machinery and microelectronics technology has resulted in the development of industrial robotics. Robots are not created from new technologies, but rather result from the combination of existing technologies. Industrial robots merge the functions of the machine and the functions of the human operator. Future robot improvements will focus on increasing the functions of artificial intelligence and sensing. The sensing functions allow robots to relate to their working environment. These sensing functions provide robots with the capability to inspect, count, locate, and orient parts in the manufacturing process.

Definition

As defined by the Robot Institute of America, "a robot is a reprogrammable multifunctional manipulator designed to move material, parts, tools, or other specialized devices through variable programmed motions for the performance of a variety of tasks" (1982, p. 1). Unlike humans, robots have the capacity to perform repetitive tasks with great precision, and unlike other machines, robots can be taught new tasks and use new tools.

Tasks that robots are capable of doing can be classified as pure displacement, displacement and processing, and displacement and inspection. Pure displacement functions include the loading and unloading of machines, parts manipulation, and palletizing. Displacement and processing functions include spot and continuous welding, mechanical and electrical parts assembly, spray painting, cabling, and cutting. Displacement and inspection functions include the machine tool operations of deburring, drilling, grinding, routing, metal die casting, hot and cold forging, and foundry operations of sand casting and investment casting.

Robots designed for materials handling, spot and continuous welding, spray painting, and foundry applications can handle a payload of up to fifty pounds. The heavy payload robots were the first to be adopted in manufacturing sectors. Assembly applications are just beginning to be developed. Most assembly robots handle less than five pounds, although the largest assembly robots can handle fifteen pounds. Assembly robots differ from other robots in that they must have a higher level of precision and repeatability.

The widest application of robotics in the United States has been in welding activities, with 34 percent of all robots used for such applications. Another 20 percent of the robot population is used for machine loading and unloading, with 19 percent used for foundry applications. Thirteen percent of all robots are used for other applications, and 12 percent are used for painting and finishing. Only 2 percent of all robots are currently used for assembly functions (Robot Institute of America 1982).

Each generation of robots represents a machine that is technically superior to robots developed during the previous generation. Robots in current use are third- or fourth-generation robots. These robots are programmable, but do not have advanced sensing capabilities. Advanced sensing capabilities will be included in the fifth through the seventh generations of robots, and the "intelligent" robot will begin to be developed in the seventh and eighth generation. Intelligent robots will have decision-making abilities and will be easier to interface with the manufacturing process.

Usage

Estimates of the current population of industrial robots in the United States range from five thousand to seven thousand in 1982 (Hunt and Hunt 1983). There is currently one robot for every four thousand production workers in America. In the auto industry, the ratio approaches one robot to four hundred workers. When trying to identify the potential for growth in this industry, consider that there is one machine to every three workers in the auto industry and one for every two within the metalworking industries.

The auto and metalworking industries are a fertile source of diffusion of industrial robots given current applications. Although tenfold increases in the number of robots in the next ten years appears to be likely, when considering the number of firms that could potentially implement robotics, it could be argued that sufficient opportunity exists for a fiftyfold increase in the application of robots in industry (Carnegie-Mellon University 1981). However, not until the problems of intermingling robotics technology and the production process are solved will widespread application be possible. The retrofitting of robots to current production processes presents a significant problem to industry today.

Influences on Usage

The rate of adoption of robots in industry depends on a variety of factors. Some of these factors relate to economic influences (e.g., the wage rate of workers in the industry or the actual cost of the robot), whereas other factors depend on future [illegible] of robotics technology. Uncertainty about future [illegible] in each of these areas interacts with the projec[illegible] of future diffusion of robots in industry.

[illegible] of labor versus capital investment. The interplay between the price of labor and capital investment is a major deter[illegible] the decision to install robots (Diebold 1983). Payback [illegible] these accounting procedures that determine whether [illegible] company will invest in an industrial robot--include, as [illegible] consideration, the yearly salary and fringe benefits of [illegible]. As the price of labor rises or robot costs decrease, [illegible] decreases. Thus, the faster labor costs rise [illegible] faster [illegible] costs decline, the more widespread will be the diffusion of robots.

[illegible] The [illegible] of robots varies by type of application. [illegible] heavyweight materials handling capacity average [illegible] whereas lightweight assembly robots can be purchased for [illegible]. The final cost, after adding peripheral [illegible] modifications to the production proc[illegible] interface with existing machinery and [illegible] approach three times the cost of the original [illegible] investment (Hutchins 1983).

[illegible] includes taking the entire cost of [illegible] (robot plus related equipment) and [illegible] the sum of the various anticipated pro[illegible] factors. These factors include the savings in wages and fringe benefits for any worker(s) replaced, savings derived from increased productivity, savings from robot depreciation, and the [illegible] maintenance and operations staff and equipment. Companies [illegible] want to break even on robot installations within [illegible] half to three years.

[illegible] robots have been purchased by multimillion[illegible] companies. There are, however, a growing number of [illegible] manufacturing organizations that are instal[illegible].

[illegible] interface. A major impeding force to the diffusion of ro[illegible] the multitude of problems associated with installing ro[illegible] getting them to work in conjunction with other manufac[illegible] equipment and processes. One problem is the low level of [illegible] capabilities of robots. A human worker on the assembly[illegible] a part out of a bin, inspects that part for defects [illegible] by sense of touch, orients that part to the [illegible] of the assembly process, and then completes the assembly task. [illegible] a robot (of the current generation) to be able to [illegible] this same assembly task, the parts presented to [illegible] already be inspected and the orientation of the parts [illegible] consistent with the assembly process. Only when all of these interfacing actions have been completed can the robot pick up the part and perform the assembly. Thus, the relatively low-skilled job of picking up a part and placing it on the product to be assembled becomes a very complicated task when automated. As robot capabilities of sensing increase, the interface problems of parts inspection and orientation will be lessened.

Significant interface problems result from the lack of an industrywide standard to allow computerized machines in a production facility to communicate with one another. The American National Standards Institute is currently attempting to develop standard interface specifications for public dissemination in 1984 or 1985. However, even when this standard is developed, there will be no enforcement of these standards except via market forces. Industry observers believe that the final industry standard will be set by one prominent manufacturing company that has a big share of the market. At this writing, whether such a market leader will emerge is still uncertain.

Once these software standardization problems are solved, it will be possible to design the production process on one computerized machine at a centralized location, transfer the specifications into the computerized production machines on the production line, and then feed information about the production from one production robot to either a centralized computer or to other robots. Currently, machine interface requires case-by-case development of communication capabilities.

The implementation of integrated systems concepts will provide significant changes for the robotics industry. The application of the sophisticated computer-integrated manufacturing systems will shape the future of the robotics industry. Robots will be integrated into self-contained manufacturing cells where equipment is linked together via a central computer with numerous programmable machines, such as automated materials handling machines, other robots, and numerically controlled machine tools. These computer-controlled machines will communicate data on production factors with each other. Until communication capabilities are developed, integration problems will impede the application of robots in industry.

Assembly. Widespread application of assembly robots is expected in the next several years. The automobile industry will use assembly robots to produce such small parts and components as distributors, door panels, and small transmissions, as well as to drive screws. Other industries, particularly those involving the assembly of electronic components, are expected to automate some assembly functions. Since the price of labor is lower in electronic components assembly operations than in the automotive assembly operations, assembly applications are expected to be adopted faster in the automobile industry.

The automobile industry remains the dominant industry for robot application. Over half of the robots installed around the world are in the automobile industry. Industry analysts predict that automated assembly operations will dominate the market within several years (Mullins 1983). Assembly requires almost 40 percent of automobile manufacturing time. The industrial robot is the key in the configuration of machines in automated assembly. Two changes will have to be implemented to facilitate this advancement: (1) automobiles will have to be designed to make assembly less complicated and (2) as many sub-units as possible must be preassembled.

Projections of Usage

The robot industry, established in 1970 in the United States, began to grow in 1980. The growth rate for 1984 to 1990 is expected to average 35 percent per year, with the largest diversification in welding and materials handling applications (McElroy 1983). Significant growth is also expected in assembly applications.

Three major studies address the issue of the future of the robotics industry and the social impact of robots. These studies include (1) a Delphi study of managers and engineers in user and producer firms, sponsored by the Society of Manufacturing Engineers (Smith and Wilson 1982); (2) the Carnegie-Mellon study (Ayres and Miller 1983), based on a survey of corporate users; and (3) the Upjohn Institute report (Hunt and Hunt 1983), which used earlier robotics studies and considerable contact with users to estimate the number of robots in 1990 in order to develop both a high and low estimate. These studies provide the best source of data on the future of robotics.

Given the range of market forces that can affect the marketability of robots, it is not surprising that the forecasts of the 1990 robot population vary. Hunt and Hunt (1983) provide both a high and low estimate of one hundred thousand and fifty thousand robots, respectively. Ayres and Miller (1983) identify the existing potential market in 1982 for robots as four hundred thousand units. They define the potential market as the demand for robots if the selling price of a 1981 model robot that costs $50,000 is reduced to $10,000. In their view, the primary impeding force for market acceptance is the fact that current vintage robots are not as cost-effective as humans in most jobs. Private market studies from such firms as Prudential-Bache and Daiwa estimate the 1990 robot population to be approximately one hundred thousand units (Hunt and Hunt 1983), whereas the Robot Institute of America (1982) estimates seventy-five thousand to one hundred thousand units in use in 1990. All of these estimates conclude that the robotics industry, overall, will experience continued growth for the remainder of this decade.

Displacement. As robots replace human labor, the general rule is that one robot will replace one human production worker per shift. To maintain and oversee robot operations, for every five to ten robots in use, only one worker per shift is required. Therefore, for every five to ten robots installed in production, five to ten production workers are displaced per shift, while one worker is hired to maintain and oversee robot operations. This robot installations create a potential for displacement of workers. Displacement in this context means the elimination of particular jobs, not the layoff of individual workers. To be cost-effective, robots are generally used in facilities that run more than one shift, with the most cost-effective applications in threeshift facilities.

All three studies estimate the percentage of certain occupational groups that could be displaced by robots. Hunt and Hunt (1983) and Smith and Wilson (1982) estimate actual displacement, whereas Ayres and Miller's (1983) estimate reflects potential displacement (see table 1). Although these estimates vary greatly, they consistently show that robots will have employment impacts on each of these occupations. Hunt and Hunt (1983) further translate their displacement figures into estimates of actual numbers of displaced workers. They estimate that, by 1990, one hundred thousand to two hundred thousand workers will be displaced, with nearly 50 percent of that displacement in machine loading and unloading applications. If assembly applications are successful, Hunt and Hunt estimate that another 25 percent of displacement will result from robotic assembly applications.

Data from the Delphi survey indicate that, in this decade, only 6 percent of the workers who are replaced by robots will be terminated. Half will be trained for a new position in the plant, another quarter will be transferred without needing training, and 13 and 6 percent, respectively, will be retrained and transferred to a new plant or will retire (Smith and Wilson 1982). These data imply that, although robots will replace human labor, the vast majority of displaced workers will be absorbed into other activities in the same companies.

The data from Smith and Wilson (1982) reflect industry optimism that robot installations will not have massive displacement effects. However, Ayres and Miller (1983) and Hunt and Hunt (1983) point out that, although nationwide displacement of workers will not be a serious problem, greater than average displacement effects will be felt within regions where there are heavy concentrations of metalworking industries. The Great Lakes states of Ohio, Michigan, Illinois, Indiana, and Wisconsin have heavy concentrations of workers in metalworking industries, as do California, New York, and Texas. "These states, and especially Michigan, are likely to experience greater than proportionate

TABLE 1

PERCENT OF OCCUPATIONAL GROUP TO BE DISPLACED, VARIOUS STUDIES

	Robotics Studies		
Occupational Group	Hunt & Hunt[a] (percent)	Delphi Survey[b] (percent)	Ayres & Miller[c] (percent)
Welding	4-7	27	10
Painting	9-15	44	5
Machine loading/ unloading	4-8	20	15
Assembly	1-3	10	6

[a]Hunt and Hunt (1983, p. 83).

[b]Smith and Wilson (1982, p. 70). Data reflect actual displacement rates.

[c]Ayres and Miller (1982, pp. 97-99). Data reflect the proportion of work done by these occupational groups that could be performed by level 1 or level 2 robots, not actual displacement.

impacts of robotization on employment in the next decade" (Ayres and Miller 1983, p. 216). Thus, although there probably will be no national displaced worker problem resulting from the installation of robots into manufacturing, certain states will likely experience such unemployment effects.

Training Implications

Skills Required

The manufacture, use, and maintenance of robots require new combinations of skills. These combinations blend three traditional fields of study: electronics, pneumatics, and hydraulics (Tanner 1982). The heaviest emphasis is on the electronics concepts, with nearly 70 percent of robotics concepts based on AC/DC electronics theory. The electronic components serve as the brain and the sensory system of robots, while the hydraulics and pneumatics provide the muscle. In addition to knowledge of these three fields, robotics workers need to understand applied concepts of computer languages, microprocessors, programmable controllers, servo systems, blueprint reading, and control theory.

Although these skills relate specifically to the technical aspects of robot manufacture, use, and maintenance, these same skills can easily be adapted to other application areas. All flexible automation machines function on these same basic concepts. Thus, the skills required to function as a robotics technician are readily transferred to other flexible automation jobs. There are only slight differences in the training requirements for other flexible automation applications.

Three techniques are used to program robots to perform the work required. Lead-through programming is accomplished by physically moving the robot's arm through the path that the robot is to follow. The robot remembers this path and repeats it, with little programming skill required by the operator. The table-top computer (or small control box) technique requires the human operator to define movements for the robot by identifying the coordinates. This technique is also very user-friendly and requires a minimal amount of training. Off-line programming of robots requires more traditional computer programming skills. Often this programming is done by personnel in other sections of the facility. The program is then transferred into the robot memory. Generally, a process engineer or design engineer has responsibility for the programming task, not the robotics technician.

Training Requirements

Cincinnati Milacron, one of the leading American manufacturers of industrial robots, can train a factory worker who has a basic knowledge of electronics to perform in-house maintenance of robots in two weeks (Tanner 1981). Delphi survey respondents indicated that maintenance personnel can be trained in fourteen days, whereas production scheduling and equipment operator training requires ten days (Smith and Wilson 1982).

Nearly every manufacturer of robots provides equipment-specific training to plant personnel. This training includes a brief overview of basic electronics, pneumatics, and hydraulics theory, and equipment-specific training for maintenance.

Conclusions

Hunt and Hunt (1983) estimate that, by 1990, twelve thousand to twenty-four thousand workers will be functioning as robotics technicians. Current indications are that the vast majority of these robotics technicians will be current or laid-off employees who have been retrained. In the automobile industry, where the majority of robots are in use, laid-off autoworkers will be called back to work and retrained before any newly trained robotics technicians will be hired. In the electronics industry, where robot usage is expected to continue to grow, electronics technicians can easily be trained by manufacturers to provide maintenance services. Thus, there appears to be little demand for newly trained robotics technicians in the next decade.

Even though many vocational education institutions are offering robotics technician courses and student enrollments are steady or increasing, institutions should note that job-related placement will be low for the majority of new robotics students. Programs should counsel students appropriately. Whenever possible, curricula should be expanded to include all flexible automation technologies rather than a focus only on robotics. Job placement possibilities are enhanced for students with flexible automation training.

Vocational educators need to weigh their decision carefully about offering programs for robotics technicians. Although there may be greater demand for students trained for broader applications (e.g., flexible automation technicians), workers who are already in the labor force will be stiff competition for newly trained robotics technician students.

CHAPTER 3

OFFICE AUTOMATION

The many applications of the semiconductor are the technical basis for the rapid growth of information and communication technology. This technology expands the capacity of human intelligence by providing and processing information in quantities that previously were not possible. Computers, the machines that embody this technology, continue to expand in capability and application. Computer technology can be found today in virtually every industry and occupation, ranging from satellite communications to homemaking.

Information is the commodity computers process. Unlike other commodities, information is an unexhaustible resource. It is not reduced in quantity or quality by repeated use; rather, its value tends to increase with repeated circulation. Information sharing, namely communications, is a convergence industry (Rada 1980). Applications resulting from this technology provide the direction for innovations taking place in other industries. The availability of information through computerized communications opens a vast array of knowledge to nonspecialists. The technology itself has increased the amount of information available. The quantity of information processed utilizing information technology is increasing so rapidly that a greater percentage of workers at all levels, including managerial and clerical, is becoming involved in the handling of computerized input and output.

One area that is and will continue to be heavily affected by information and communication technology is general office work. Three factors contribute to the magnitude of this impact. First, capital investment in the office is low in comparison to capital investment in manufacturing and agriculture. Second, the service sector has shown relatively low productivity increases over time; thus, in order to stimulate growth in the economy, productivity must be increased in the service sector and, more specifically, in the office. The nation cannot continue to rely on the industrial and agricultural sectors for continued productivity growth to stimulate the economy. Third, current office labor costs are much higher than those experienced in the past, and are continuing to rise (Rada 1980). In 1979, office labor and benefits cost $600 billion in the United States. Optimists predict an 8 percent annual increase in the cost of office labor and benefits, or $1.3 trillion by 1989, whereas pessimists forecast a 12 percent annual increase, or $1.8 trillion by the end of the decade (Avedon 1983).

Definition

In the short run, office work will experience the greatest effects of information technology. In the office, information technology serves as a tool to increase productivity and, in turn, aids in the organization of work. The generic term office automation (OA), is currently used to refer to an array of equipment used in the office, much of which is based on microprocessor technology.

Equipment comprising the OA environment includes copiers and typesetters, dictation equipment, electronic typewriters, facsimile equipment, private branch exchanges (PBXs), personal computers, and word processors. Various configurations of this equipment are linked through local area networks along with other devices, to allow the transmittal of information between specific pieces of equipment internal and external to the office environment.

In 1964, IBM first used the term word processing to describe all automatic equipment that assisted in the preparation of text (Rada 1980). Currently, this definition encompasses everything from typewriters possessing memory capabilities and used as stand-alone systems, to shared-logic systems in which a number of peripheral devices make use of a central computer system.

A word processing system can be configured in basically three ways: (1) as a stand-alone system, (2) as a shared-logic system, or (3) as a distributed system. Stand-alone word processing systems contain a number of basic components, including a terminal, a processing unit, internal storage devices, and a printer, which together allow the system to function as a single entity.

Shared-logic word processing systems possess a central processing unit (CPU), in which all intelligence is contained. The individual components comprising each word processing system are able to operate at a considerable physical distance from the main processing unit, but are unable to operate or function without it. Each unit functions only by sharing the logic or intelligence contained in the central processing unit. If the communication link between each individual word processing station and the CPU is severed, the station ceases to function.

The final system, termed a distributed system, allows stand-alone and/or shared-logic systems to share resources to form one large system. In a distributed system, each individual system is capable of operating independently. This allows for the intelligence to be distributed throughout the overall system. In addition, this type of system allows for the component systems to be physically located virtually in any part of the world (Information Management June 1983).

The introduction of the integrated/multifunction system further encourages the move away from the standard word processing system. The term multifunction system came into use when companies began utilizing their existing computer systems for word processing applications through the addition of software or incremental capabilities ("Office Systems for the Eighties" 1983). This type of system not only performs traditional data processing functions, but also serves in a word processing capacity (thus the term multifunction). The term integrated system refers to the capability of the multifunction system to interface with a central computer system or other multifunction system, allowing for the exchange of information between systems.

Usage of Technology

As the economy continues to experience growth in the service industries (specifically in transportation, utilities, trade, financial, government, health, and other services), increased amounts of information will be processed, placing a greater emphasis on productivity growth and on more efficient methods of processing and disseminating information. Thus, the impetus to automate various functions of the office has become increasingly prevalent.

During the next five years, forecasts indicate that manufacturers will sell \$118 billion worth of office automation equipment, including copiers, personal computers, word processors, and typewriters, and PBXs ("Office Systems" 1983).

The personal computer (PC) has already begun to saturate the office automation market. Due to the flexibility and decreasing costs of personal computers, many businesses, large and small, have adopted the use of PCs as a viable alternative to unifunctional word processing systems. One forecast indicates that almost \$50 billion worth of PCs will be purchased by American companies by 1987 (ibid.) whereas other forecasters speculate that sales to American businesses will reach only \$6.6 billion (Electronic Business 1983). By 1991, some experts anticipate that from 20 to 50 million personal computers will be in use by the business sector in the United States (Blundel 1982; Office Equipment 1983).

Even with increased competition from personal computer sales in the office automation equipment market, some forecasters expect sales of word processing equipment to American businesses over the next five years to exceed \$20 billion ("Office Systems" 1983), whereas others predict sales of word processing systems to reach only \$4.4 billion by 1986 (Electronics 1983). Dataquest Inc., a market research firm in California, forecasts that, by 1984, the installation of word processors with display capabilities will total nearly 1.2 million units (Harrison 1982). By

1992, usage of these systems by American businesses is predicted to increase to 6.3 million units (Datamation 1983).

Expected shipments of other office automation equipment, namely copiers and PBXs, are predicted to reach $18 and $19 billion, respectively in the next five years. Although the sales and usage figures for personal computers and word processors are widely dispersed, every source predicts significant growth in the office automation market in the next three to five years.

Influences on the OA Environment

Although growth is projected for the office automation market, industry observers speculate that two factors may limit this growth over the next five years. The first is the continued lack of standardization of OA equipment. In many instances, certain hardware modifications will allow interfacing between various pieces of equipment, but the capital investment required to realize this capability is extensive.

The second factor is the cost of and rapid rate of change in office automation equipment in general. The evolving nature of technology in the information system/office automation environment constantly reduces the cost of equipment. Smaller firms that are presently considering making a capital investment in this area may, in fact, be induced to hold off in anticipation of future technological enhancements and cost reductions. It is anticipated that larger firms will continue to make capital investments for OA equipment in the next three to five years.

Training Implications

The increasing usage of integrated/multifunction systems in the OA environment is expected to improve the productivity of all office workers. Although increased productivity and efficiency are usually associated with reductions in personnel, actual demand for workers possessing clerical skills is expected to grow throughout the decade. Clerical occupations currently account for more jobs than any other occupational group. Clerical positions account for 18.5 percent of all jobs in the economy, with secretarial and typist jobs accounting for one out of every five clerical positions (Carey 1981). The U.S. Bureau of Labor Statistics identifies secretaries and typists as the fourth- and eighth-ranked occupations in projected growth in terms of average annual job openings between 1980 and 1990, with expected average annual job openings of 575,000 and 299,000, respectively, per year (Hecker 1983).

A major trend is the reconfiguration of the OA environment, namely in the use of word processing equipment. The movement from the stand-alone word processing system toward an integrated/multifunction system is taking place in the office today. The anticipated growth of the integrated office system will require skilled personnel trained in both word processing and basic computer skills (Haverson 1983). In addition, training will be required to aid workers to understand how such equipment as dictating machines, copiers, PBXs, and personnal computers are integrated to form a productive and efficient system.

The additional skill requirements needed by OA personnel have drawn concern from industry users as to who will satisfy these new training needs. Currently, the majority of OA training is conducted in individual firms by experienced personnel within the firm, using material supplied by vendors or developed internally (Haverson 1983). Many firms lack a qualified training staff and the facilities to conduct such training. Compounding this problem is the attitude of top managers within many firms who call for reductions in OA training budgets (Haverson 1983).

The need to develop alternative sources of training is readily apparent. Research (Cowan 1983) conducted for Kelly Services Inc., a temporary help firm, indicates that 78 percent of word processing operators acquire basic word processing skills in their present job. Temporary office personnel services across the United States are attempting to meet the training needs of the future, but are experiencing limited success. Results of a survey of word processing managers, supervisors, and specialists conducted by Office Administration and Automation (Cowan 1983) indicated that temporary office personnel are somewhat useful in meeting "basic" word processing needs, but lack the technical competencies needed for more complicated applications.

In the past, information processing, including word processing and information storage and retrieval, was typically performed by persons working in clerical positions. The automated office of today (and of the future) will not only affect the activities of the clerical staff within organizations, but will also affect the day-to-day activities of managers as more managers will be performing tasks that have typically been classified as clerical tasks. Word processing divisions in organizations are providing women with opportunities to advance into managerial positions, thus aiding in the breakdown of the stereotypical role of women as clerks and men as managers.

Vocational education institutions at both the secondary and postsecondary levels are in a favorable position to satisfy the training needs of OA staff for the future, at both the clerical and managerial levels, for traditional and nontraditional vocational education students. Inherent to OA training at both the secondary and postsecondary levels are basic computer literacy skills, which include training in keyboard skills and a general orientation to computer hardware components and how they interface with other equipment and systems. Skills training in these areas will become increasingly crucial as the OA environment moves from an independent entity towards an integrated environment.

There is some concern that the importance of keyboard skills will diminish with the introduction of voice input technology. The trend away from keyboard input toward voice input will not affect training in keyboard skills in the next few years. High costs associated with voice-deciphering technology and imperfections inherent in the current technology will impede the rapid adoption of voice input equipment.

The influx of personal computers into the OA environment providing multifunction capabilities (including word processing) will stimulate a demand for individuals with higher-order skills, including analysis, comprehension, and logical thinking. With the increasing capabilities of office automation equipment to interface with mainframe computer systems, the need to provide individuals with a macrolevel understanding of system operations and with higher-order skills is further underscored. Although there continues to be a need for individuals with more traditional office skills, there will be a decrease in the number of new job openings for individuals without higher-order skills.

A second training market exists for managerial-level personnel. As the automation of the office evolves, a greater percentage of managers will utilize personal computers and dictation equipment to increase productivity in the office. Managers will require training or retraining in (1) skills needed to operate the new automated equipment and (2) in a basic understanding of how the use of such equipment can increase productivity and efficiency in their respective office environments. Training for managerial-level personnel can best be served by adult and continuing education programs in postsecondary institutions. Managers constitute a market that has been relatively underserved by these institutions.

Traditionally, sharp lines of distinction have separated the business education curricula and other curricula within vocational education programs. As information processing equipment is infused into the business world, a greater number of persons outside of the business education area will require training in information technology. Thus, a substantial training market exists at all levels of vocational education for groups requiring an orientation to or skills training in information technologies.

Finally, a training market exists for students not normally participating in vocational education, particularly for college preparatory students in secondary and postsecondary institutions. Applications of information technology exist in many professions and occupations outside of the vocational education arena. A prime opportunity exists for vocational education at the secondary and postsecondary levels to serve the relevant training needs of students not normally participating in vocational education.

In summary, training implications are apparent for vocational education at both the secondary and postsecondary levels. Currently, there is a need for word processing training for entry-level personnel and retraining needs for the acquisition of higher-order skills in analysis, comprehension, and logical thinking. As businesses spend less on office automation training, a prime opportunity exists for vocational education to provide this training now and in the future.

APPENDIX

CONVENING PARTICIPANTS

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