DOCUMENT RESUME

ED 216 168 CE 032 430

AUTHOR Faddis, Constance; And Others
TITLE Preparing for High Technology: Strategies for Change.
INSTITUTION Ohio State Univ., Columbus. National Center for Research in Vocational Education.
SPONS AGENCY Office of Vocational and Adult Education (ED), Washington, DC.
REPORT NO NCRVE-R&D-Ser-230
PUB DATE 82
CONTRACT 300-78-0032
NOTE 47p.; For related documents see CE 032 429-431.
AVAILABLE FROM The National Center for Research in Vocational Education, National Center Publications, Box F, 1960 Kenny Rd., Columbus, OH 43210 (RD 230, $4.25; quantity discounts available--see last page of document).

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Change Strategies; Computer Oriented Programs; Curriculum Development; Demand Occupations; *Education Work Relationship; Employment Opportunities; *Employment Projections; *Futures (of Society); Job Skills; Manufacturing; Manufacturing Industry; Paraprofessional Personnel; Postsecondary Education; Program Development; Program Improvement; Skill Development; *Technical Education; Technical Occupations; *Technological Advancement; Technology; Telecommunications; Training Methods; Two Year Colleges; Vocational Education
IDENTIFIERS Technology Adaptation Project

ABSTRACT

In order to help postsecondary technical colleges to keep abreast of changing technology, a study was conducted (1) to investigate the current and future status of three high technology areas in terms of their impacts on occupations, labor demand, and training requirements; and (2) to provide guidelines to help colleges change their programs to meet the demands of these changing industries. The first section of this report presents a brief survey of the impact of new technologies on selected industries and occupations. The technological innovations reviewed are telecommunications, computer applications, and advanced manufacturing technologies (including robotics). Each review includes examples of major applications and leading user groups. Effects of the innovations on labor demand and occupations are reported and forecasts of anticipated effects on job content, skills, and skill levels are reviewed for workers in technician-level jobs. The second section presents an analysis of technological advancement in the marketplace and the ways postsecondary colleges can respond to such advancements. Recommended strategies for early assessment and a more rapid and successful response by postsecondary colleges are discussed. (KC)

Research & Development Series No. 230

Preparing for High Technology:

Strategies For Change

Constance Faddis
William L. Ashley
Robert E. Abram

The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road
Columbus, Ohio 43210

1982

THE NATIONAL CENTER MISSION STATEMENT

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Providing information for national planning and policy
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

For further information contact:

Program Information Office
National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road
Columbus, Ohio 43210
Telephone: (614) 486-3655 or (800) 848-4815
Cable: CTVOCEDOSU/Columbus, Ohio
Telex: 8104821894

Cover photograph courtesy of *Robotics Today*.

FUNDING INFORMATION

Project Title:	National Center for Research in Vocational Education, Applied Research and Development
Contract Number:	300780032
Project Number:	051MH10012
Educational Act Under Which the Funds Were Administered:	Education Amendments of 1976, P.L. 94-482
Source of Contract:	U.S. Department of Education Office of Vocational and Adult Education Washington, D.C.
Contractor:	The National Center for Research in Vocational Education The Ohio State University Columbus, Ohio 43210
Executive Director:	Robert E. Taylor
Disclaimer:	This publication was prepared pursuant to a contract with the Office of Vocational and Adult Education, U.S. Department of Education. Contractors undertaking such projects under government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official U.S. Department of Education position or policy.
Discrimination Prohibited:	Title VI of the Civil Rights Act of 1964 states: "No person in the United States shall, on the grounds of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." Title IX of the Education Amendments of 1972 states: "No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance." Therefore, the National Center for Research in Vocational Education Project, like every program or activity receiving financial assistance from the U.S. Department of Education, must be operated in compliance with these laws.

TABLE OF CONTENTS

FOREWORD

Postsecondary technical colleges have, since their inception, responded to the training needs of business and industry through a variety of training programs for youth and and adults. In recent years, however, American business and industry has had to confront an alarming drop in its productivity while struggling with rising unemployment and inflation. To slow the decline in productivity, if not reverse it, business and industry is beginning to invest in an array of sophisticated technological devices and processes that promise to deliver products and services more efficiently and, it is hoped, with improved quality. Unlike past technological innovations, advancements associated with the current generation of innovations have accelerated more rapidly than in the past. These developments would seem to be reason for considerable optimism for the future. Optimism is warranted assuming that, in addition to the designers and producers of the new technological wonders, there are individuals trained to know when to use them, how to use them, and how to keep them operating efficiently. In short, we have available a new genre of "smart" machines with great potential for increasing productivity. But training for the technicians who will use and maintain the "smart" machines has just begun. This training needs to be expanded and accelerated if the technolgoies of tomorrow are to provide us with the needed improvements in productivity and competitiveness.

The current study was initiated by the National Center for Research in Vocational Education to investigate the current and future status of three high technology areas in terms of their impacts on occupations, labor demand, and training requirements. The three areas selected for study are telecommunications, computer applications, and advanced manufacturing technology.

A second effort in this study focuses on the presentation of a model of technology transfer and diffusion from the perspective of a user or adapter of a technology. This effort also includes a discussion of response options of postsecondary colleges to technological advancements as these are reflected through technician-level training needs.

The study's products will enable postsecondary planners and administrators to explore the impact of advancing technologies to determine if and when a response is appropriate and to become familiar with various response options for developing high technology programs or course sequences.

The project staff would like to express appreciation to Molly Orth, Dr. Brian Fitch, Dr. James Weber, and Dr. Richard Ruff of the National Center, Dr. Carol Fought of the Columbus Technical Institute, and Newton Brokaw of the Columbus Industrial Association, who served as reviewers of this report. Their valuable suggestions were used to improve the presentation and interpretation of materials. Also of help in revising the draft was Catharine Warmbrod of the National Center Janet Kiplinger of the National Center Editorial Services area provided an editorial review of the manuscript.

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

EXECUTIVE SUMMARY

The first section of this report presents a brief survey of the impact of new technologies on selected industries and occupations. The technological innovations reviewed are telecommunications, computer applications, and advanced manufacturing technologies (including robotics). Each review includes examples of major applications and leading user groups. Effects of the innovations on labor demand and occupations are reported and forecasts of anticipated effects on job content, skills, and skill levels are reviewed for workers in technician-level jobs.

The second section presents an analysis of technological advancement in the marketplace and the ways postsecondary colleges respond to such advancements. Recommended strategies for early assessment and a more rapid and successful response by postsecondary colleges is discussed.

INTRODUCTION

The Problem

American business and industry are currently struggling with an alarming decline in the growth of productivity. The disquieting fact is that productivity growth has not only slowed over the past few years, but has recently actually declined (Thurow 1981). After studying the problem and potential solutions in this country and abroad, many business and industry leaders are seeking to boost their companies' productivity through the adoption or adaptation of new machines and processes associated with advanced technological innovations.

One of the most important of the new technologies is the microprocessor. Its versatility in industrial, business, and domestic applications makes it one of the most pervasive technological innovations in modern times. Its revolutionary applications in the computer industry, in particular, have had profound impacts on how workers and machines interact to provide products and services in virtually every office and factory in the United States (Osborne 1979).

The current wave of advanced technology has begun to produce a fascinating array of devices and products, but with only passing regard for the effects these will have on the work force. The development and production phase of the advanced technologies is outstripping the availability of a trained work force to operate and maintain them. One example of this skill-shortage dilemma is the rapidly growing area of robotics, in which there is a shortage of trained technicians capable of monitoring and servicing the expanding array of industrial robots (Stauffer 1981). Shortages of trained technicians are also appearing in the use of computer graphics technologies, biomedical engineering technologies, and electro/optical equipment.

This research project was undertaken to review a selected number of postsecondary school programs that are preparing technicians for work in advanced technologies. Of particular interest in the effort was the nature of collaboration between two-year postsecondary schools and local businesses and industries that facilitated development and operation of the training programs. In addition, the project sought to review the current and probable future status of selected technologies, and to identify resources to aid postsecondary school planners and concerned industry representatives in understanding possible impacts of changing technologies on future labor demands, occupations, and skill requirements for technicians. These latter activities are the focus of this report.

Purpose and Methods of the Project

The Technology Adaptation Project was an initial investigation of successful roles and approaches being used by two-year postsecondary education institutions to assist business and industry in adopting or adapting advanced technological innovations as a means for improving productivity and aiding economic growth. This review and synthesis of literature and resources is intended to serve as a sample for information-gathering and updating activities for postsecondary institutions and/or businesses and industries concerned with developing or upgrading technician-level training programs in two-year postsecondary schools.

Sources for the brief technology impact reviews included ERIC and the Social Sciences Retrospective information systems at the Mechanized Information Center, The Ohio State University Libraries. In addition, selected manual searches were carried out at the research library of the National Center. Other sources of information were obtained from consultants, interviewees at field sites, and staff members at the National Center. The specific technology overviews are, by the necessity for brevity, restricted to three sample technology areas. The selected areas are telecommunications, computer applications, and advanced manufacturing technology.

Materials for the "Resources" and "Selected Readings" listings were obtained from the sources mentioned previously. The listings are organized into a number of categories to facilitate identification of topics of interest or focus. Categories include a wide range of technology changes and issues; technology transfer; and the impact of changing technology on local and national economies, on industry training, on labor and employment, on occupations, on productivity, and on postsecondary vocational education.

Material for the second section is based primarily on the information and observations of the site visit team as well as the literature reviewed during the early stages of the project. The material is used to construct a model to describe how technology progresses from innovation to practical application. Site visit material, particularly the interviews conducted with postsecondary program planners and administrators, also served as an information base for describing how postsecondary colleges are currently responding to technological advancements and strategies for reducing delays and improving the effectiveness of such responses.

PART I

Assessing Changing Technologies

A BRIEF SURVEY OF THE IMPACT OF NEW TECHNOLOGIES ON SELECTED INDUSTRIES AND OCCUPATIONS

Introduction

In order to understand the effects that the adoption of advanced technologies is having or may have on American industries and workers, three areas of important technological innovation and expansion are reviewed here. The three are: telecommunications, computer applications, and advanced manufacturing technologies (including robotics). These areas serve as examples of how changing technologies are affecting businesses and industries, labor demand, and workers themselves, especially in terms of the demands for training or retraining in technician-level occupations with technology-related skills.

In each of the technology areas reviewed, major examples of kinds of technological innovations and users applying those innovations are reported. The effects the innovations have on labor demand and on occupations are drawn from reviews of literature dealing with labor and technology. Finally, forecasts are reviewed for anticipated effects that the technological innovations will have on job content, skills, and skill levels for workers in technician-level jobs Each technology area reviewed is briefly summarized.

The literature reviewed to prepare this overview included journals such as *Technology Review*, *Dun's Review*, *Fortune*, *International Labour Review*, *Social and Labour Bulletin*, *The Futurist*, *Monthly Labor Review*, and similar publications. Conference reports, such as *Technology Assessment and Occupational Education in the Future* (Sniegoski 1979), and research reports, such as *Science and Technology: A Five-Year Outlook* (National Research Council 1979), are examples of the kinds of expert opinion used.

The overview of changing technologies does not attempt to be definitive. It represents ways that a concerned vocational educator, administrator, or advisory committee could collect vital information on trends in technological change (and its effects on labor and skill demands) by reviewing literature available in journals and documents. (Lists of selected journals and documents, as well as of other resources, are included elsewhere in this publication.) Such information, which can be gathered inexpensively and with only moderate time and effort, can be crucial to those involved in planning, developing, or updating programs or curricula in high-technology areas.

The utility of this information for participation in local or regional economic development efforts is also high. By monitoring information on technology changes, with attention to supporting economic, political, and social factors, educators can lessen the probability of encountering unexpected shifts in local training needs. Postsecondary faculty, representing a wide range of interests and expertise, also can be pivotal in heightening the awareness of local employers about technological innovations, the ease or complexity of adopting or adapting them, and the potential of these innovations for boosting productivity. Finally, by maintaining an awareness of emerging technologies and trends in labor/skill demands, postsecondary institution faculty should be better able to anticipate national patterns and use that knowledge to create appropriate high-technology training programs that will attract new industry to the region, help create new jobs, and aid in the entry and advancement of local workers in technician-level jobs in American industry and business.

Telecommunications

New Technologies, New Users

The field of telecommunications is one of the most rapidly changing industries in the world, driven by innovations and declining costs of microprocessors, fiber optics, laser beam transmission, computers and computer systems, microwave transmission hardware, coaxial cables, and synchronous-orbital communications satellites. The microelectronic revolution is less than a decade old, yet its impact on our society and on the world as a whole has affected the speed, availability, cost, and effectiveness of every kind of communication. It has made information, entertainment, and data manipulation available to government, business, the military, and private citizens. Uses of telecommunications are expected to expand by the end of the eighties, bringing us into an era that futurists are calling "the global village."

Prime examples of developers and users of new and emerging telecommunications technologies include—

- telephone companies and services (such as American Telephone and Telegraph Corporation, Southern Pacific Communications, and others),
- cable television networks, stations, and businesses (such as Cable News Network, Warner-QUBE, and so forth),
- national and local weather-forecasting services,
- United States defense systems, the National Aeronautics and Space Administration, and national/international satellite surveillance and mapping systems (such as LANDSAT),
- Automatic Teller Machine (ATM) networking by banks,
- computer-accessed networks, such as Compuserve, The Source, etc., which serve small business and personal networking needs,
- stock market brokers, bankers, and other financial managers,
- radio, television, and news networks and "superstations" (such as CBS, Cable News Network, Atlanta's WTBS, United Press International, and so forth).

Examples of the technologies affecting telecommunications are data networks, satellite and digitally-encoded telephone and telecopy devices and systems, optical fibers and cables, electronic mail and shopping services, text editing and distribution systems, and electronic funds-transfer systems. Potential future technology applications, such as inexpensive bubble memories and Josephson junctions, may make telecommunications even faster, more accurate, and able to handle larger bulks of data (National Research Council 1979).

Telecommunications Technologies and Work

The adoption or adaptation of new technologies in an industry affects the industry and its work force in many ways, among which are labor demand (job creation, job obsolescence), occupations (new occupations emerge, old occupations vanish, occupational clusters change due to increasing specialization), and job content and skill requirements. Studies of changes in telecommunications industries and their patterns of employment provide some data for forecasting likely trends in labor demand, occupations, and job content and skill requirements. The focus here is on technician-level jobs—those of importance to one- or two-year technical or community colleges.

Changes in labor demand. Manufacturers of telecommunications equipment are being dramatically affected by the applications of microchip circuitry. For example, an electronic telex manufactured by the West German company, Standard Electric Lorenz, now has one microprocessor in place of 936 moving parts in an earlier model; its manufacture requires only about eighteen hours, compared with seventy-five hours for an electromechanical telex. Telecommunications Ericson in Sweden reduced its work force from 15,000 to 10,000 workers between 1975 and 1978, and employment in telecommunications manufacturing in Britain dropped from 88,000 workers to 65,000 during the same period (Norman 1981a). This has been the trend all over the world in that industry.

Installation and maintenance labor can be expected to be similarly affected as advanced technologies continue to be adopted in the telecommunications industry. For example, do-it-yourself telephone installation has already drastically reduced the phone installation force of the Bell System across the United States, and some maintenance functions presently performed by the industry also will be transferred to the customer in the 1980s. This will be made possible by the expanding use of microprocessors, coupled with the modular assembly of telephones and other telecommunications equipment design changes. Developments such as dedicated plant lines (permanently installed lines and connectors in commercial and residential buildings), buried cable, and quick-connect terminals are reducing labor demand (as well as skill levels) for line and cable workers (Dymmel 1979).

Other telecommunications jobs will also be affected by the new technologies. New switching equipment has affected the number of telephone operators in the past, dropping the percentage of the industry's total employment from more than 50 percent in the mid-1940s to less than 20 percent of the industry's work force today. This decline may not continue in the 1980s, however, as increasing demand for services is expected. Some experts in the industry feel that unless a new technology is discovered for jobs still performed by operators, their share of employment may even increase (Dymmel 1979). Advances in artificial intelligence (such as computer verbal/oral discrimination and decision-making capacities) and mechanical voice simulation may nevertheless eventually depress the demand for human operators.

The potential widespread adoption of electronic postal services, shopping services, and home computer terminals may affect labor demand in the postal system, in newspaper printing and distribution, book publishing, retail and wholesale sales and distribution, and—via electronic funds transfer—banking and financial manipulation. Forecasters concerned with the technology expect that mail carriers, printing tradespersons, distribution and delivery workers, and bank tellers will experience a decline in labor demand.

Changes in occupations. As seen in the previous section, changing telecommunications technologies will have a direct effect on almost every occupation. In the telecommunications articles reviewed here, however, there was no direct implication that any particular occupations in the telecommunications industries would totally vanish.

The only emerging telecommunications occupational area that was mentioned was that of laser technicians (Orth and Russell 1980). According to that report,

> Requirements for technicians in terms of absolute numbers are unclear. Future demand depends on how much business and industry will use lasers either for the first time or in an expansion of uses in existing areas, such as the communications field. For example, lasers are coming into use for the transmission of images across the country for newspaper copy. It is reasonable to assume that the use of lasers will continue to expand in the future. The capability of fiber optics and lasers to communicate a vastly increased amount of information (as compared with electronic transmission) and fiber optics' resistance to electromagnetic deterioration seem to ensure expanding usage, with consequent increased demand for skilled technicians in those technologies. (p. 84–86)

Changes in job content, skills, and skill levels. In the telephone industry, most technician-level jobs are involved either with switching systems or with signal transmission. New electronic switching systems (ESS):

> ... require less labor and different skills than older systems. ESS machines are preprogrammed to fit each specific office; therefore, skill requirements are reduced considerably for craftworkers who install these systems. Similarly, less maintenance is required because ESS monitors its own performance and diagnoses circuitry problems. ESS also is changing skill requirements. The system has no moving parts, thereby eliminating the need for mechanical repair skills. However, knowledge of electronic computer-based systems and programming concepts is required. Thus, the technical skills and educational requirements are increasing for ESS-related work. (Dymmel 1979, p. 14)

Changes in transmissions systems (including coaxial cable networking and multiplexing) are expected to alter skill requirements significantly for transmissions system craftworkers The use of fiber optics may reduce skill requirements, because the optical systems involved will be preengineered and the equipment at the ends of the transmissions systems (i.e., equipment in central offices) will remain principally electronic. Central office craftworkers will retain their current approximate skills levels, but "dedicated plant lines, buried cables, and quick-connect terminals are expected to lower skill levels of line and cable workers" (Dymmel 1979, p. 14–15).

Changes in skills levels for satellite-communications technicians are not expected to be significant in the near future. According to Dymmel:

> Modest employment growth can be expected in these fields as satellite use becomes more extensive. At present, satellites provide only supplemental capacity and, therefore, have not affected personnel at ground-based transmission facilities. (Dymmel 1979, p. 14–15)

How the success of the space-shuttle system (which is scheduled to put numerous satellites into orbit for a variety of purposes) affects the employment of ground-based satellite communications technicians remains to be seen, however. The use of direct-beam television transmission by satellite could well affect the need for installation and service technicians—perhaps displacing cable-television transmission technicians.

Summary: Telecommunications

Observers of the telecommunications field seem to agree that labor demands in general are decreasing and will continue to do so, with telecommunications manufacturing workers, installation and maintenance labor, and possibly telephone operators suffering the most job decreases. Potential areas of growth are cable-television company technicians, laser technicians, and ground-based satellite transmission technicians.

Only a few specialized new occupations are expected to emerge (e.g., laser technicians), and the demand for workers is not expected to be substantial. No direct telecommunications occupations are expected to vanish entirely, though the demand for some workers is already decreasing, as mentioned. Almost every occupation—or job within an occupational cluster—in the telecommunications industries is expected to undergo changes in job *content*, however, as well as in the skills and levels of skills required. Because of engineering design and the proliferation of computerized monitoring systems, most manufacturing, crafts, and installation jobs will probably require lower skill levels than before, particularly for mechanical skills, though an increase in demand for computer systems and programming skills is likely to raise the skill levels in some of those occupations.

Labor-management cooperation in the telecommunications industry has notably affected the decline in employment, slowing it. (This is not unique to the telecommunications industries.) This trend is expected to continue through the eighties.

> Most [labor] contracts contain general provisions relating to seniority, layoffs, part-time work, and severance pay that afford some protection against the effects of technological change. ... Increased emphases will be placed on retraining employees for the new technologies or for different types of jobs, while slowly decreasing the size of the work force through attrition. (Dymmel 1979)

The new technologies in telecommunications also affect employment of women.

> Women workers historically have constituted a major portion of telephone industry employment. They have been concentrated in operator and clerical positions until recently, when they moved gradually into male-dominated craft jobs. Moreover, technological changes in the last two decades have adversely affected jobs traditionally held by women more than jobs held by men in construction, installation, and maintenance occupations. Thus, although the number of women workers increased more than 15 percent from 1960 to 1977, their share of total employment fell from 57.2 percent to 48.9 percent. However, if operator employment does not decrease significantly through the 1980s, and greater numbers of craft jobs open to women, their share of total employment may stay near 50 percent. (Dymmel 1979)

Women may be expected to have major roles in all aspects of future telecommunications industries.

Computer Applications

New Technologies, New Users

The advent of microprocessors is as intimately bound to new computer applications as it is to the telecommunications field, and its impact is equally sweeping. The incorporation of microprocessors together with optical scanners, electrostatic printers, laser-imaged discs for information storage and retrieval, telecommunications equipment, and so forth, is revolutionizing data processing, information storage and retrieval, word processing, automatic accounting and inventory control, publishing, printing, and entertainment. Industries directly involved with or affected by the new computer applications include automobile manufacturing, banks, insurance firms, retail and wholesale businesses, computation instrument/calculator manufacturers, newspapers, health care facilities, libraries, and electronic game manufacturers, among others. Probably no industry exists in the United States (or in other industrialized countries) that is not being affected by new or emerging computer applications. Even the agriculture and the fishing industries are using computers.

Types of jobs and occupations directly involved in computer-using industries that are currently or are likely to be significantly affected by the new applications include computer operators and programmers, retail salespersons, data-entry technicians, typists and secretaries, insurance claims processors, editors and printers, accounting and inventory workers, installation and maintenance workers, manufacturing workers, and so forth. Few, if any, occupations are left untouched by the new technologies.

Examples of the new applications of computer technologies include word processors and "smart" typewriters, computerized optical-scan point-of-sale devices (which simultaneously keep a running inventory of products), automatic bank tellers and account validation systems, library cataloging systems, computerized traffic control systems, home computers, hand-held programmable calculators/computers, electronic games, aviation simulators, control systems for automatic ventilation and heating, electronic postage scales, computerized machine tools, computerized typesetting, and so forth.

Computer Application Technologies and Work

Changes in labor demand. Microprocessor applications seem likely to affect clerical workers first and perhaps most strongly. "It has been estimated that at least 30 percent of clerical jobs will be lost by 1990 as the impact of the word processor makes itself felt" (Farley 1980). A 1978 report to the president of France projected that by 1990, 30 percent fewer workers would be needed to produce a given volume of work in the insurance and banking industries.

> The British insurance company, Friends Provident, is already developing its own internal services by transacting through a nationwide network of display terminals, which also provide for the composition and printing of policy documents and the automatic handling of premium payments. This "instant policy" system has, they claim, virtually eliminated all paper work from what was a notoriously paper-bound process. ... The Services manager of Friends Provident anticipates a staff savings of 40 percent, which will pay for the cost of installing the system. (Norman 1981a)

A study (Magarrell 1980) at Stanford University estimated that the university now spends more than $35 million a year for typing, filing, and retrieving textual material. The director of the university's Center for Information Technology reported that the number of clerical employees at the university grows at an annual rate of 4.5 percent, but that a computerized records-processing system would cut that growth rate in half, while saving the university at least $11 million over the next five years.

Another recent study has forecast that the introduction of microelectronics into office equipment in Switzerland would entail the loss of some 250,000 office jobs in that country by 1983 ("Effects of New Technologies" 1980b). A British forecast projects a minimum job loss in excess of

36,000 over the next ten years due directly to the proliferation of word processors there, with a possible maximum loss of 260,000 jobs by 1989 ("Effects of New Technologies" 1980a).

Not all employment analysts agree with this grim scenario for office workers. The *Occupational Outlook Handbook* put out by the U.S. Department of Labor (1976-77 edition) forecasts an increase of more than 30 percent in employment for clerical workers between 1975 and 1985. Also, according to Bradbury and Russell (1980), "Word processors are not reducing clerical numbers. They have an advantage of giving secretarial type support to managers where previously this was not available." *Business Education Forum* also proposes that computerization of offices in the United States will not dramatically affect labor demand for office workers in this decade:

> While there is an obvious shift to more automation in the office, we need to remember that our huge data files are created by workers keying necessary information into a machine. These workers are trained office employees. Whatever is meant by the paperless office, it is not going to appear overnight, it is not going to operate without manpower [sic], and medium and small business is not going to be an immediate participant in these new systems. ("Business Education" 1980)

Furthermore, some futurists predict that the use of computers and other "intelligent" machines will lead to increased employment in some areas.

> Computer programming, for example, is a labor-intensive activity that is a likely source of many thousands of new jobs in the eighties. Demand for programmers is already outstripping supply, and some analysts have even suggested that this shortage could constrain the growth in the use of computers in the coming years. (Norman 1981b)

An increase in demand for "source keying" (information entry and retrieval) workers is also expected.

Inroads have also been made by computer technologies on printing and journalism-related industries. Computerized phototypesetter machines are replacing old, mechanical linotype machines. The computerized equipment outperforms the mechanical machines and has already eliminated some jobs while drastically altering the skills required by the operators. Electronic paste-up computers vastly streamline layout work and have reduced the demand for skilled layout artists and changed the skills they require.

The proliferation of mini- and microcomputers in businesses and in homes and the development of information networks for them may open jobs in maintenance and service, as well as in data entry/updating work (except for keypunching, which is becoming an obsolete technology), and other information-handling occupations, such as journalism and editing. These may not be newly created jobs, however, but primarily crossovers from newspapers and so forth.

Changes in occupations. Technology can create major changes in occupations very quickly. Twenty-five years ago, computers were a minor field, but by 1978 there were 800,000 jobs in the computer industry (Orth and Russell 1980). The occupations of computer programmer, analyst, and operator were simply not open before the mid-1960s. A number of new occupations are emerging as a result of the newer computer technologies, including composing machine operator, word processing specialist, and records management technician.

As computers become vital to more businesses and industries, specialized data-entry-and-retrieval occupations may develop, an example of which is a tumor registrar. Such a worker, according to the National Tumor Registrars Association, will work:

. . to establish and maintain the efficient operation of a tumor registry; to register and follow patients with a diagnosis of malignancy; to retrieve and analyze registry data [using a computer or computer network]; to disseminate the data in accordance with professional ethics. (Orth and Russell 1980)

Such specialized data-manipulating occupations may combine with many existing occupations in other areas of health care, in the insurance industry, in education, in environmental and consumer protection, and in a multitude of other service industries.

Changes in job content, skills, and skill levels. In surveying computer-related occupations, it quickly becomes obvious that many office jobs, clerical and retail positions, and other support services will require a working knowledge of computer software, at least at an elementary level. The majority of computerized office equipment is available with inservice training from the manufacturer, or comes with simple instruction manuals or aids (such as PLATO) that provide self-instruction on the machine as it is used. The majority of Computer-Aided Instruction (CAI)—and the use of the software purchased with the equipment—is designed and packaged for extreme simplicity, however, and the level of skill required to use such machines is likely to remain relatively low.

Most observers of emerging computer applications believe that the technology's proliferation will have adverse effects on skill levels. Cherns (1980) pointed out that "computerized warehouses have reduced or eliminated the skills of storekeeping and the self-supervision of warehousemen [sic]." According to the German Union of Salaried Employees, the 30,000 word processors installed in that country's offices so far have "created jobs with high stress components, resembling work at the assembly line. Apart from increased health risks, this development leads to deskilling" ("Effects of New Technologies" 1980a).

So-called foolproof software for word processors will streamline the work, but also reduce it to "something anyone can do." Cherns (1980) suggested that computerization is currently being adopted in ways that:

. . . fragment jobs and reduce the employee's autonomy. . . . Word processing departments have now centralized and devalued the secretary. Some organizations have not recognized the diseconomies that result from such applications and have attempted to redesign jobs accordingly. . . . So far it is fair to say that redesign has done no more than restore in a few organizations the skills and autonomy that went with clerical jobs before the computer reduced them; I cannot report any instance of the computer being deliberately used to upgrade clerical jobs.

Opposing perspectives do exist. For example, Schramm (1980) suggested that computerizing offices offers opportunities for greater job expansion and satisfaction for clerical workers:

While some observers denounce the repetitive nature of an operator's work and consider that it is more and more akin to the fragmentation of tasks found on an industrial production line, others, more optimistic, argue that the clerical or secretarial worker is at last relieved of certain disagreeable tasks, typing speed is attended to by the machine, the need for large numbers of carbon copies and corrections is a thing of the past, etc. The secretary is, in short, freed for more important administrative tasks such as verification, planning, and organization. Uhlig, Farber, and Bair (1979) also anticipate greater job satisfaction for office workers, resulting from the increased efficiency of some office processes and the elimination of others through office computerization.

Some of the professionals' administrative status may be shifted to secretaries, along with lower-level decision and management responsibilities. This could result in secretarial positions (under a different title) becoming entry-level managerial jobs.

Summary: Computer Applications

Declines in labor demand for office workers are forecast, due to proliferation of computerized office equipment (especially of word processors) in the 1980s. This pattern of decline is not anticipated by some American analysts. Some job losses may be expected in printing industries, however. Job gains are predicted for computer programmers, maintenance and service workers, operators, and analysts, as well as for other information-handling occupations (except keypunchers). New specialized data-manipulating occupations that combine indepth knowledge of a particular area (such as health care) are expected to emerge or expand in many businesses and industries.

Skill requirements in many occupations, especially in office work, may decline somewhat, due to simplification of tasks involving use of computerized equipment. Use of the equipment itself is not expected to require high skill levels. Another perspective suggests that computerization will relieve many workers of disagreeable tasks and will free them for more important ones.

A British report pointed out that there are some other, work-related effects of computerization of offices:

> Although microtechnology will create new jobs, it is extremely unlikely such job creation will be on a matching basis [that is, that new jobs will equal staff reductions]. And, because most jobs involving typing are carried out by women, it is women who will be hit the hardest. The problem will be aggravated by the fact that the female labour force is expected to increase both in real terms and as a proportion of the total labour force. ("Effects of New Technologies" 1980a)

This report further stated that many of these office jobs are filled by youthful workers, and elimination of substantial numbers of clerical jobs will aggravate the youth unemployment problems of that country—which are not unlike those in the United States.

Computerization of office equipment may hold new opportunities for employment of the handicapped. A report from Switzerland on "talking typewriters" (audio-typing units using synthetic speech, which is a microprocessor application) proposed that the new device will give access to office jobs for the blind or visually handicapped ("Effects of New Technologies" 1980b).

Another optimistic viewpoint is Mayo's. In his article, "The Power of Microelectronics," he pointed out that—

> . . . computer science has not yet provided enough basic knowledge and tools to improve programming productivity to make full use of microelectronic technology. . . . There is simply not enough talent to program all the computers that can now be operated economically. (Mayo 1981)

Advanced Manufacturing Technology

New Technologies, New Users

Automation, in the modern sense, came into use when Henry Ford adopted the conveyor belt technology for assembly-line production of his Model Ts. Today's advanced manufacturing technologies make use of sophisticated design, fabrication, assembly, finishing, and quality control equipment incorporating microprocessor-driven control systems, lasers, programmable computerized robots, optical scanners, and an enormous array of new materials and processes. Makers of advanced manufacturing equipment (e.g., Cincinnati Milacron, TRW, General Electric, Rockwell International) have devised machines and tools that improve manufacturing accuracy, efficiency, costs, and safety for such users as the automobile industry, the aerospace industry, the construction industry, steel and other materials producers, and mining companies, as well as the home handyperson.

Advanced Manufacturing Technologies and Work

Changes in labor demand. The introduction of industrial robots that incorporate microprocessor controls, and the reduction of the number and complexity of parts in assembled products through the introduction of microprocessors into the products themselves, have already had considerable impact on labor demand in the manufacturing industry. In 1975, the National Cash Register Company (NCR) in Great Britain announced that its work force there was reduced by over 50 percent since 1970 as a direct result of the company's introduction of microprocessors into its products in order to remain competitive (Farley 1980). In the United States, NCR reduced its American work force from 37,000 workers to 18,000 workers between 1970 and 1975, because its electronic cash registers required only 25 percent of the labor required to produce the company's earlier mechanical or electromechanical models (Norman 1981b). The introduction of robot welders in automobile assembly has resulted in a boost of 20 percent in productivity, at a reduction of 10 percent in the labor force at the General Motors plant in Lordstown, Ohio (Norman 1981b), and this is only one plant in a major industry.

Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) are revolutionizing manufacturing. CAD not only speeds up the laborious process of drafting, it also enables the designer to simulate various aspects of an object or assemblage by rotating, disassembling, and reassembling it on a computer screen, as well as testing it under a variety of known, simulated conditions. At General Motors' Fisher Body Division in Warren, Michigan, the use of on-screen CAD testing saves enormous expense and time that otherwise would have had to be spent in fabricating prototypes for testing and design modifications.

CAM, computer control of production machines, ranges from machine tools running on punched-tape instructions to robots that can be reprogrammed to perform a variety of complex industrial tasks. Such robots outperform human operators in speed, accuracy, and dependability in many tasks. When CAD and CAM are linked together, their advantages are magnified. At Pratt and Whitney Aircraft Corporation, turbine blades (as well as other aircraft parts) are manufactured directly from CAD drawings, with the entire production process automated. In many cases, CAD has allowed gains of 5:1 or 6:1 reduction in labor, and at least a 2:1 reduction in lead time. These ratios go up to 30:1 and 50:1 when CAD is linked to CAM (Bylinsky 1981). The potential for labor displacement by CAD–CAM systems in other manufacturing industries is clear.

In the textile industry, the pattern is the same. New technology is expected to replace as many as 300,000 textile workers in the United States by 1990. Pattern-cutting robots utilizing computer controls and laser cutting have already reduced skilled labor requirements in a British garment manufacturing plant from 200 employees to only 20 (Bylinsky 1981). Microprocessor-controlled sewing machines may similarly affect the task of clothing construction (Lund 1981).

In agriculture, advanced technology is being incorporated into mechanical harvesters. In California, farmworkers claim that the introduction of such harvesters for lettuce and wine grapes will replace as many as 40,000 jobs by 1982 ("Effects of New Technologies" 1980b).

Manufacturing and mining industries in West Germany give an overview of the general trend of labor reduction brought about by the introduction of advanced manufacturing technologies there:

> From 1970 to 1977 production in the manufacturing and mining industries in the Federal Republic of Germany increased by 13.5 percent, while employment dropped by 14.5 percent (in total, 1.246 million persons) and the volume of employment (number of persons X worked hours) decreased by 21.3 percent, productivity per hour having increased by 44.3 percent. The figures for producers of office and data processing machines are even more telling: occupying third place in the production growth (48.9 percent), that sector lost 20,600 jobs (25.8 percent) while productivity per hour grew by 105.5 percent. ("Effects of New Technologies" 1979)

The employment picture is not entirely bleak, however. The machine tool industry in the United States has been plagued by skilled labor shortages over the past ten years. Employment dropped 40 percent, from 111,000 in 1969 to 76,000 in 1974, then stabilized around 80,000. When the auto industry began retooling to meet federal safety and fuel-efficiency standards, United States machine tool manufacturers were caught with too little a capacity and too few employees to fill the deluge of orders, resulting in back orders of up to two years (Adkins 1981). Analysts blame the skill shortages on the machine tool companies' lax attitude toward training skilled labor.

The area of industrial maintenance, which employs mostly skilled workers, is expected to grow in number by 3 million new jobs by 1990 (Sniegoski 1979). In addition the manufacturing maintenance occupations (involving thirty-four maintenance-related positions, according to the *Dictionary of Occupational Titles*) are expected to lose half their members during the eighties due mainly to retirements, as a large portion of those skilled workers are currently older than fifty (Barker 1979). The "growing complexity of equipment, plus automation of production processes, is actually increasing the need for maintenance technicians at a faster rate than the rest of the work force," according to Barker; by 1990 the need for new maintenance workers may be as high as 1 million per year.

The pharmaceutical industry is exploiting automation but does not seem to be suffering significant reductions in levels of employment. What it is experiencing is a change in skill balances with new training needs (Bradbury and Russell 1980).

Significant levels of job loss will not be experienced in every manufacturing industry, but as Norman (1981b) points out, "the potential range of microprocessor-based automation is very broad." The new technologies are boosting productivity, but it may be a "jobless growth."

Changes in occupations. As noted above, new manufacturing technologies are making a number of occupations obsolete, particularly semiskilled and skilled occupations such as patterncutters and sewing machine operators in the textile industry. No evidence was found that specific new occupations will emerge as a result of the new technologies, though existing occupations such as machinists, maintenance/repair workers, and the many other manufacturing technician occupations are likely to change in job content as they incorporate knowledge and skills in such areas as laser operation, robot control, and computer operation.

Changes in job content, skills, and skill levels. The new manufacturing technologies seem likely to create the need for new skills and may decentralize decision making to some degree. The consensus of observers seems to be, however, that the new technologies will decrease skill levels in general and eliminate some skills entirely.

> A report by the Machine Tool Task Force, a project funded by the U.S. Air Force, recommends that industry "reduce the skill levels required to operate or maintain certain machine tools (or to plan the manufacture of a part), an approach already practiced by some of the technically more advanced companies. This can be done by using more automation and substituting computers for people in executing certain decisions or operations." (Shaiken 1981)

The designers of machinery are indeed making major efforts "to deskill the operation of their machines" (Sniegoski 1979). Moreover, in *The Machinist Shortage*, Schultz (1980) claimed that "large companies have been putting as much work as they can onto computer tapes to be performed by semi-autonomous machining centers," and that jobs that cannot be computerized economically "are being broken down at the drafting table into steps that can be performed by less skilled machine operators." This shows that a deskilling of manufacturing occupations, through adoption of certain machinery and the redesign of manufacturing processes, is indeed underway.

On the other hand, case studies conducted by the University of California at Berkeley show only slight decreases in the overall levels of skill required in manufacturing jobs in the steel and aerospace industries: "The general conclusion ... was that automation has no substantial effects on skill levels, particularly once the installation and 'debugging' stages are passed" (Organisation for Economic Cooperation and Development 1966). It should be noted, though, that this research was performed before the advent of microprocessors, and its current validity is questionable. It is reasonable to expect, as mentioned earlier, that at least some manufacturing technician jobs will require an expansion of skills in such areas as laser operation, computer programming, and numerical control system maintenance and repair.

Summary: Advanced Manufacturing Technology

The new manufacturing technologies seem likely to affect employment levels, occupations, and job and skill content in all aspects of product manufacture and use. These technologies will dramatically increase productivity, but this will tend to be a "jobless growth," resulting in little actual job creation. Exceptions are likely to be in maintenance and repair jobs, laser technician jobs, and some specialized computer-related jobs.

Those occupations not likely to survive the influx of new technologies may be agricultural harvesters for certain farm produce (such as wine-grape pickers), garment industry workers in pattern-cutting and garment fabrication jobs, and semiskilled laborers (such as riveters, loaders, and so forth) in manufacturing/assembly jobs. In those jobs that will be retained, job content and skill levels seem likely to change, although no general trend is clear. Some jobs will require entirely new skills, and many will require at least an elementary ability to work with computerized control systems. In addition, the simplification of production machinery, made possible by the advent of microprocessor control systems, will result in deskilling in some jobs, particularly in fabrication and assembly.

PART II

Responding to Changes in Technology

RESPONDING TO CHANGES IN TECHNOLOGY

Introduction

Changing technologies have left their marks on human civilizations throughout history. Of all the ways changing technologies affect societies, one of the most significant is the way the changes affect the nature of work and jobs. This realm was the primary focus of the Technology Adaptation project. The project was designed to identify advanced technologies that have or are expected to have significant impacts on technician-level jobs in the 1980s, and to investigate exemplary one- and two-year postsecondary programs that represent successful responses to technological change. The differing roles that postsecondary institutions have taken in addressing local and regional economic development opportunities were also examined, particularly as they related to aiding in technology transfer and job creation.

The following are a number of conditions colleges may encounter that can inhibit quick and effective responses to advanced technologies:

- The fast pace of technological change is itself a significant condition, as exemplified by the rapidly spreading adoption of sophisticated technologies in telecommunications, manufacturing, computer applications, medical diagnosis and treatment, transportation, and other fields.
- The changing nature of educational requirements for jobs is the second condition complicating school response. Examples encountered by the current research include the changing roles and skills needed for design and production work in the emerging computer-based manufacturing and telecommunications systems.
- Because of the speed and revolutionary nature of many new technical advances, access to up-to-date information needed to design core courses and programs is seriously limited. Few experts and skilled workers exist who can be approached for advice and information; the potential advisors often are not situated near the school, even when program planners manage to locate them.
- Traditional approaches and techniques for planning, developing, approving, and implementing new programs can be too slow or inappropriate for some high-technology training needs. A concern for programs with public funding is that of justifying their existence on the basis of occupational demand, usually in the form of statistics on available jobs. If a school responds early, the statistics may be insufficient for program approval, and if the school delays, the eventual response may not help companies that are early adopters of emerging technologies. The delay in providing trained technicians may be crucial in some industries for attaining or maintaining high productivity and competitiveness.
- Another condition is the burden that developing high-technology programs places on school staff. These individuals often have limited time outside of teaching duties to spend

on systematic development and upgrading activities or on upgrading their own technical skills. The latter may not even be possible in some technology areas; current project findings suggest that hiring instructors with engineering backgrounds as full-time or adjunct faculty is considered more appropriate than trying to upgrade instructors whose work experience and education predates the emergence of the advanced technologies.

- Limited information, funds, equipment, and qualified instructional staff affect quality, response time, and relevance of postsecondary programs. Program quality and content relevance are key factors when a company is considering providing assistance and/or support to a school. Further, companies on the "leading edge" of new technologies may shun graduates from local programs because the competencies developed are not considered relevant to the companies' needs. They may favor graduates from programs in other schools and states who have competencies closer to company hiring requirements.

Alternative Response Modes

As technological innovations progress from the developmental stage to the applied stage, their initial use or application by business and industry can pose a dilemma for postsecondary colleges: When should a two-year college initiate a training program to meet the need for new skills and knowledges that emerge as a new technology is translated into jobs by users and producers?

Three modes of responding are proposed as options from among which a two-year college can choose. The three modes are the "early," "fast-follow," and "delayed" response modes. An institution may employ one or more of these response options at different times and in different situations (see Table 1). All three modes may be implemented simultaneously when addressing different technological training needs.

TABLE 1

Characteristics of Three Response Modes
by Postsecondary Colleges in High Technology

Response Mode Characteristics	*Postsecondary Response Modes*		
	Early	*Fast-Follow*	*Delayed*
Enrollment	Speculative	Variable	Stable
Technology Transfer	Initiates	Initiates and supports	Supports
Industry Expansion	Attracts expanding industry	Supports expanding industry	Maintains extant industry
Program Changes	Frequent	Regular	Occasional
Availability of Curriculum	Little or none	May be available but not widespread	More readily available
Availability of Qualified Instructors	Few or none	Limited	More readily available
Employment Demand	Limited	Expanding	Steady, depending on the economy
Availability of Cooperative Position	Limited	Expanding	Steady, depending on the economy

The relative differences represented by the three response modes are defined as follows:

- *Early response mode.* Institution responds prior to the emergence of a technology in the local region—may establish planning committees with potential users, develop preliminary course plans, initiate inservice training for teachers, and/or conduct seminars, workshops, and conferences to introduce new technology to private sector firms.
- *Fast-follow response mode.* Institution responds soon after new technology is first adopted by local users—may conduct fast-start training sessions, develop and conduct core courses, begin full program development, and expand offerings as number of users increases.
- *Delayed response mode.* Institution responds after new technology is well established among regional users—courses and programs are developed to meet job opportunities when future growth of the technology is ensured.

The early and fast-follow modes can optimize the rapid adoption of new high-technology innovations, leading to improved productivity, product quality, and local economic development. A delayed response can also be an appropriate course of action for an institution depending on certain factors that can affect the success of a new program.

Factors to Consider

A number of factors can affect the timeliness, effectiveness, and long-term success of postsecondary programs developed under the early and fast-follow response modes. Findings from the site visits, discussions with both educators and employers, and reviews of other research suggest that there are at least three factors.

- *The nature and adoption rate of a technology* in local or regional business and industry sectors
- *The level of planning, cooperation, and resource sharing* among government agencies, educational institutions, and business and industry groups
- *The existence of flexible institutional capabilities* essential to the rapid development, delivery, and maintenance of courses and programs in high-technology fields

Each of these factors is discussed in the following sections, and suggestions for assessing each one are offered.

The Nature and Adoption Rate of Technology

Technology is the totality of any human endeavor designed to extend our capabilities beyond their natural limits. All technologies can be classified according to three general levels of development—low, intermediate, or high, with high-level technology development prevalent in the heavily industrialized countries of the world. The distinction among levels is based on the extent to which a technology extends human faculties. Briefly stated, low-level technology encompasses primitive tools and simple machines powered by animals or humans. Intermediate-level technology incorporates improved tools and machines, such as metal tools, and compound or complex machines having interrelated parts and powered by humans, animals, or natural sources (e.g., wind, water). High-level technology includes complex machines and tools driven by power sources other than human, animal, or natural—that is, using internal combustion, electricity, hydraulic, or pneumatic power sources instead. High-level technology, through the use of modern computer technology and sensory systems, can incorporate elements of humanlike analytical, mathematical, decision-making, and memory processes (Pytlik 1978).

The term "high technology" is commonly used today when reference is made to the state of the art or emerging technologies such as solid-state integrated circuitry "chips," fiber-optic and laser transmission systems, computer networks, space flight guidance systems, and complex self-monitoring and computer-controlled devices.

Technology is the result of developmental experiences and tends to evolve through several major stages. This is particularly true for many advances and improvements in modern high-technology fields. The stages of technology development include basic research, applied research, and the experimental development stage. If a commercially viable product is developed, it will be introduced into the marketplace and will continue to pass through a product cycle (Hirsh 1965). From the perspective of the user or adapter of a technology, the phases can be described as (1) the early innovation stage, (2) early adoption stage, and (3) later adoption stage. (See Figure 1.)

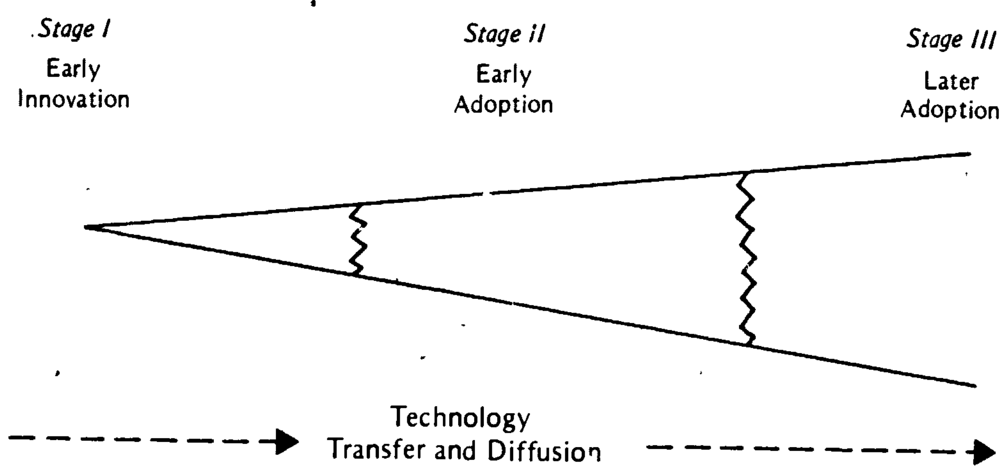

FIGURE 1

Stage I represents a point in the development of a new innovation at which one or only a few organizations have access to it. At this stage, the new innovation is assumed to have emerged from the purely research stage and has reached the practical application stage.

Several types of organizations are typically the early innovators. Private companies, both large and small, government-sponsored R&D agencies, university research departments, and private inventors are the primary members of the early innovator group. The more advanced technologies and the more research-intensive and costly developments generally will be found among large corporations and government research agencies. However, in terms of many practical innovations that require more creative thinking than basic research, smaller companies and private inventors are often the successful innovators.

Stage II organizations are the early adopters and are typically the initial purchasers of new technology. If the technology is expensive and designed for a particular market (such as large-scale applications), the initial adopters will be those companies that have the necessary capital to purchase the technology and are of such size or structure that they can achieve the intended efficiency designed into the new technology. However, a technology can be designed to serve the needs of a greater variety of users, and will thus appeal to a larger market.

The amount of time required for an innovation to move through the several phases of adoption will vary with the kinds of innovations and the particular needs of potential users. Innovations that contribute to direct and immediate reductions in the users' cost of producing their own primary products or services may be adopted more rapidly than innovations that are only secondarily beneficial to the users' operations. For example, if skilled labor is plentiful and less expensive than investing in new capital equipment (i.e., robots), then a firm may defer acquiring the new equipment until some future date.

In another situation, an innovation may have some potential application but will require additional development and modification before it can be incorporated into existing operations. In such a situation, many potential users may delay adopting the innovation until it has received further refinement and can be more easily integrated into their system. Also, many potential users may not have the capital or capability to conduct the necessary further development required to adapt an innovation to their particular needs.

The rate at which an innovation is being adopted can be measured approximately by finding out how many new users (individual firms) acquire (purchase/lease) the new product in a given period of time (month/year). Variations of this measure include the adoption rate of new users in different technical fields and among firms of different size. These additional measures can indicate the rate at which an innovation (e.g., word processing systems) is being adopted in different types of business organizations as well as the direction of the adoption trend (e.g., large firms first, small firms later).

In order to understand more fully the potential impact that a particular technology might have on future human resource requirements, consideration must be given to several aspects of the technology adoption and transfer process. Technology transfer involves the transfer of information and the devices or products essential to the application of a given technology.

There can be both a "vertical" and a "horizontal" dimension to technology transfer. Technology moves along the vertical dimension from the general to the specific, from theory to application. Vertical transfer also refers to the diffusion of a technology within a particular industry. Along the horizontal dimension, the use of technology is transferred from one field of application to another, from one type of industry to another. Horizontal transfer includes the diffusion of a relatively standard product to many potential users, but also results, through the process of adaptation, in the establishment of new uses that are different from the original ones. In reality, a particular technology may move through several phases, from innovator to early adopter to later adopter, while it is also being adapted to new uses and being introduced into new fields of application. For example, in the United States, producers of a particular line of products (machine-tools) generally market their products and new product innovations to customers in diverse fields. In such a market system, a new innovation developed for one client can be quickly diffused to many different users.

In the educational field, new discoveries and new knowledge coming from the frontiers of scientific research move vertically down through the technical institutions and become incorporated into the body of knowledge on which program content is based. Because there are many variables in the adoption and diffusion of technological innovations, educational planners should assess the potential impact of technological changes on the education and training requirements of occupations that might affect their institution's programs. The selection and timing of program responses to technological changes should be made on the basis of such an assessment to ensure that the most appropriate response is chosen. Additionally, the assessment can help to ensure that sufficient time, resources, job opportunities, and student interest are available to support new program initiatives.

Assessing the technology. When assessing the nature and potential adoption of a particular technological innovation, attention should be given to its probable impact on a local region. The following are examples of questions to be answered in such an assessment:

- Is the technology generic (applicable to many users' needs; e.g., minicomputers) or highly specific (useful to a limited group of users; e.g., laser welding)?
- Are larger organizations likely to be the early adopters or will smaller firms adopt first?
- How rapidly is the innovation being adopted in other regions?
- Is the relative cost of the innovation high or low?
- Are local conditions (labor costs, type of industry, age of existing technology) favorable to rapid adoption in the near future?
- Will the adoption of a new product or process increase or decrease the amount of training required of workers and technicians?
- Will the adoption tend to increase or decrease job opportunities in the local region?

Planning, Cooperation, and Resource Sharing

A second factor that can greatly affect the early and fast-follow development and maintenance of high-technology programs in two-year postsecondary institutions is the level of planning, cooperation, and resource sharing among government agencies, postsecondary institutions, and the business and industry community. The need for advance planning and cooperation among these groups in developing high-technology programs is essential in light of the high costs and related risks frequently involved in starting such programs. Joint planning, close cooperation, and extensive support and resource sharing between postsecondary programs and the private sector often is associated with the existence of high-technology development groups, expanded advisory committee functions, and the involvement of leading high-technology corporations.

High-technology development groups. Advance planning and coordination between the private sector and local postsecondary institutions are facilitated through the assistance of special groups, such as high-technology industry councils, state government task forces for high-technology development, and/or state economic development programs focused on attracting high-technology industries. Examples of such organizations encountered in the site visits are Partners in Progress (Milwaukee, Wisconsin), the Massachusetts High-Technology Council (Boston), the Design for the Eighties program (South Carolina), and the governor's program to attract microelectronics industries to North Carolina.

High-technology development groups can help bring together representatives from the private sector and educational community to plan and coordinate activities toward common goals and to ensure complimentary growth of new industry and needed training and education programs.

Expanded advisory committee functions. A second characteristic of advance planning, close cooperation, and extensive sharing of both human and material resources between the private sector and two-year postsecondary institutions is the expanded use of advisory committees. In several of the cases studied, faculty members were provided released time to work extensively with representatives of local businesses at the companies' facilities, to plan and develop new courses and programs. Individuals from the private sector often donated many hours of their time and expertise to assist in analyzing new jobs, describing skill requirements, planning cooperative work experiences, developing curriculum materials, or providing other occupational information necessary to aid faculty in starting new courses and programs. Additionally, corporate training personnel were involved in updating the knowledge and skills of postsecondary faculty as well as sharing training information and strategies to aid instructors in developing new courses and selecting appropriate equipment.

High-technology corporations. Significant levels of resource sharing and industry support for postsecondary programs were found where institutions became involved with leading companies or organizations. This was particularly true of companies with a nationally and internationally marketed product that represented the latest stage of technological development. An example is Digital Equipment Corporation (DEC), which has provided computer equipment, related hardware, and instructor training to assist institutions that establish a Minicomputer Technology Program (MTP). Twenty-four schools are now involved in such programs and have received significant levels of support from DEC.

Cincinnati Milacron, a world leader in advanced technology metal-cutting and plastics processing machinery, has provided expensive robot equipment to universities and two-year technical institutes, and has also provided technical advice to assist institutions in developing new programs and updating existing ones in manufacturing technology.

The Tufts-New England Medical Center has provided Franklin Institute's medical electronics students with clinical internship positions that include hands-on experiences with the latest high-technology medical equipment available.

It should be pointed out that leading firms in a given technical field, particularly equipment manufacturers, are often large companies and can better afford to provide expensive equipment and resources than can smaller companies that have less equipment available and use it fully in their business operations. The contributions of smaller firms should not be discounted, however, as they often are a major source of new job openings, provide local cooperative education work experiences, participate in local advisory committees, and provide part-time instructors for postsecondary programs.

The potential for establishing advance planning, cooperation, and resource sharing among state and local government agencies, business and industry firms, and two-year postsecondary institutions should be carefully assessed when early or fast-follow responses are being considered by an institution.

Assessing potential cooperation. Many questions can be asked in assessing the local potential for advance planning, cooperation, and resource sharing. For example:

- What is the technological profile of existing local businesses and industries?
- Which local companies are manufacturers and which ones are users of high technology?
- Do business and industry groups already exist that might be willing to join in forming a high-technology council?
- What linkages exist between the college(s) and private sector that can be strengthened?
- What agencies at the state government level could play a role in establishing access to and dialog with major corporations?
- Are there local business, industry, or civic leaders who are willing and capable of initiating cooperative planning efforts in and outside of the local area?
- Can private sector firms provide needed resources and facilities?
- Are firms willing and capable of providing work stations as part of a high-technology cooperative education program?

- To what extent will local and regional companies participate in advance planning activities regarding future trends in technology adoption, emerging training needs, and commitments of resources and support for new programs?

Institutional Flexibility and
Response Capabilities

A third factor that can affect postsecondary program responsiveness in the early and fast-follow modes is the flexibility of the institution and its capacity for rapid response to emerging needs. Flexibility refers to the institution's capacity to initiate and carry out a broad range of activities without unnecessary bureaucratic restrictions and delays. Rapid response refers to the capacity of the institution or its various program areas to determine quickly the training needs of specific firms, develop new courses, quickly deliver instruction through a variety of techniques, and/or access technically competent individuals to serve as instructors.

Assessing institutional capabilities. When assessing an institution's capacity for flexible and rapid response, several specific capabilities should be examined. The following questions can serve as guides to the assessment process:

- Is there a quick mechanism for contracting directly with employers to develop and deliver special training programs?
- Are faculty allowed to provide consulting and coordinating services to aid a business or industry in solving either technical or personnel training problems?
- Can multiple tracks or course options within a program be made available to accommodate the training needs of workers from different firms or with different levels of education and work experience?
- Is there an existing procedure that allows the institution to jointly plan and conduct special seminars, workshops, or conferences with a focus on new technology and issues of special interest to local business and industry?
- Does or can the institution involve local chapters of business and industry associations and professional and trade groups in planning and developing new courses or programs?
- Will the state governance agencies develop alternative policies to facilitate more rapid program approval and special funding for early or fast-follow responses at the institution?
- What previous activities or experiences has the institution conducted that could be highlighted to demonstrate its capacities to business and industry?
- What programs and faculty competencies are in the institution that can serve as a foundation on which new programs or training activities can be built?

There are other questions that can be raised in assessing an institution's current and potential capacities to respond quickly and in a flexible manner to emerging high-technology training needs. The concern here is that institutional capacity is one of the important factors related to successful efforts to plan, develop, and deliver the needed training in emerging high-technology businesses and industries.

Strategies for Alternative Response Modes

After assessment has been made regarding (1) the impact of a technology on the local setting, (2) the potential for planning, cooperation, and resource sharing, and (3) the capability of the institution to respond, a decision can then be made as to which response mode to select.

Early response mode. If the results of the assessment support the need for an early response, the following strategies may be implemented as part of the response:

- Obtain advance information and advice from R&D labs in industry and from universities that are Involved in high-technology research projects. Because these sources can provide information about emerging technologies and innovations, programs can be planned that will be relevant when the new technologies come on-line.
- Begin to upgrade instructional staff via cooperative arrangements with high-technology companies and universities, whereby instructors spend time gaining experience with the newest equipment and processes by working in those environments.
- Recruit new instructors with recent engineering backgrounds to aid in upgrading and guiding those with more traditional backgrounds.
- Form or join an alliance with other educational institutions for the purposes of sharing the costs of developing new programs and courses in high-technology areas, sharing materials and ideas, exchanging faculty for teaching and inservice activities, identifying and sharing combined expertise and resources with businesses and industries, and mutually supporting projects in areas of common needs.
- Establish or strengthen linkages between postsecondary technical colleges and universities to utilize the university's facilities and faculty expertise, and aid in curriculum development.
- Seek funding (especially "front money" to develop new programs) from sources such as state economic development agencies, industrial associations, or foundations. Funding from these sources permits programs to be developed and implemented more quickly than by usual funding methods, which may require certain enrollment or job demand levels for program approval.
- Gain access to highly specific and expensive equipment through cooperation with related industries; or, compensate for the lack of such equipment by the use of innovative instructional approaches (e.g., using video simulation).
- Begin developing a few initial or supplemental courses in specific high-technology areas (e.g., computer graphics) to meet more immediate needs. These courses can later be expanded to create more comprehensive programs to meet long-term needs as the technology becomes more widely adopted.

Fast-follow response mode. If the results of the assessment suggest the fast-follow mode as the most appropriate course of action, the following strategies may be employed:

- Establish a panel of experts in the technology area to aid in rapid development of training courses.
- Secure technical information and materials from manufacturers of the technical products and devices to be used in training sessions.
- Seek out technically competent business or industry personnel as part-time instructors in new training courses.

- Develop a few "core courses" or supplemental units of technical instruction to meet immediate needs.
- Adopt training courses or course modules from companies that have already developed them.
- Update the knowledge and skills of key faculty members through intensive training courses available through leading industries.
- Use facilities or equipment that may be available in the private sector or local universities.
- Use cooperative training experiences to provide students with exposure to the latest generation of equipment and processes.

These strategies are specific actions that, ideally, should facilitate successful program development and operation. The ideas offered in this paper are intended to stimulate the thinking of educators and business and industry personnel toward increased joing planning, cooperation, and resource sharing to meet the current and future needs for trained technicians in high-technology occupations.

PART III

Backup Information

RESOURCES

During the course of this study, the staff became aware of a number of associations and organizations that were engaged in the research, promotion, or information dissemination of advanced technology. The following list is included in this study as an example of resources the reader may wish to contact for additional information. The list is by no means complete, but inquiries to one of the national information systems or clearinghouses should provide valuable additional leads.

Professional Organizations

Robot Institute of America
One SME Drive
P.O. Box 930
Dearborn, MI 48128

Society of Manufacturing Engineers
One SME Drive
P.O. Box 930
Dearborn, MI 48128

American Association of Community and Junior Colleges
1 Dupont Circle
Washington, DC 20036

National Association of Industrial and Technical Teacher Educators
c/o Professor Thomas Gregor
Ritter Annex 443
Temple University
Philadelphia, PA 19122

National Computer Graphics Association
2033 M Street, NW
Suite 330
Washington, DC 20036

American Society for Training and Development
600 Maryland Avenue, SW
Suite 305
Washington, DC 20024

National Society for Performance and Instruction
1126 16th Street, NW
Suite 315
Washington, DC 20036

American Electronics Association
Technology Training and Careers
P.O. Box 11036
Palo Alto, CA 94306

Society of Manufacturing Engineers

Specialties:

Robotics International of SME
One SME Drive
P.O. Box 930
Dearborn, MI 48128

Computer and Automated Systems Associations of SME
One SME Drive
P.O. Box 930
Dearborn, MI 48128

Association of Finishing Processes of SME
One SME Drive
P.O. Box 930
Dearborn, MI 48128

Laser Institute of America
4100 Executive Park Drive
Cincinnati, OH 45241

University-Based R&D Organizations

National Association of Industrial Technology
c/o School of Tecnnology
Bowling Green State University
Bowling Green, OH 43403

Department of Engineering and Public Policy
Carnegie-Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213

National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road
Columbus, OH 43210

Research Projects

Vocational Education for Economic Development Project
American Vocational Association
2020 N. 14th Street
Arlington, VA 22201

Industry-Education-Labor Collaboration Project
National Manpower Institute
Center for Education and Work
1211 Connecticut Avenue, NW
Suite 301
Washington, DC 20036

Information Centers/Systems

Office of Technology Assessment
Congress of the United States
Washington, DC 20510

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

Technology Education Research Center
8 Eliot Street
Cambridge, MA 02138

Congressional Information Service, Inc.
4520 East-West Highway
Washington, DC 20014

World Future Society
P.O. Box 30369
Bethesda Branch
Washington, DC 20014

National Network for Curriculum Coordination in Vocational and Technical Education
Sangamon State University, E-22
Springfield, IL 62708

R&D Organizations

National Aeronautics and Space Administration
Technology Transfer Division
Office of Space and Terrestrial Applications
Washington, DC 20546

National Association for Industry Education Cooperation
P.O. Box 06235
53 East Stewart Avenue
Columbus, OH 43206

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

REFERENCES

Adkins, L. "Can Machine Tools Come Back?" *Dun's Review* 117 (1981): 65–69.

Barker, D. "Industry's Struggle for Skilled Workers." *VocEd* 54 (1979): 26–28.

Bradbury, F., and Russell, J. *Technology Change and Its Manpower Implications. A Comparative Study of the Chemical and Allied Products Industry in the United Kingdom, the United States, and Japan.* Middlesex, England: Chemical and Allied Products Industry Training Board, 1980.

"Business Education: Its Status, Its Potential, and Its Needs in the 1980s." *Business Education Forum* 35 (1980): 3–11.

Bylinsky, G. "A New Industrial Revolution Is on the Way." *Fortune* (5 October 1981): 106–114.

Cherns, A. B. "Speculations on the Social Effects of New Microelectronics Technology." *International Labour Review* 119 (1980): 705–721.

Dymmel, M. D. "Technology in Communications: Its Effect on Labor and Skills." *Monthly Labor Review* 102 (1979): 13–19.

"Effects of New Technologies." *Social and Labour Bulletin* (1979): 336–337.

"Effects of New Technologies." *Social and Labour Bulletin* (1980a): 6–15.

"Effects of New Technologies." *Social and Labour Bulletin* (1980b): 135–156.

Farley, M. "The Chip: Is Time Running Out?" *NATFHE Journal* 5 (1980): 14–17.

Lund, R. T. "Microprocessors and Productivity: Cashing in Our Chips." *Technology Review* 83 (1981): 32–36, 38–39, 44.

Magarrell, J. "Computer Links Stanford Officials in Test of Electronic Mail System." *The Chronicle of Higher Education*, October 6, 1980: 5.

Mayo, J. S. "The Power of Microprocessors." *Technology Review* 83 (1981): 46–54.

National Research Council. Science and Technology. *A Five-Year Outlook.* San Francisco: W. H. Freeman and Co., 1979.

Norman, C. "The International Stakes in Microelectronics." *Technology Review* 83 (1981a): 40–41, 43.

Norman, C. "The New Industrial Revolution: How Microprocessors May Change the Workplace." *The Futurist* 15 (1981b): 30–42.

Organisation for Economic Cooperation and Development. *Manpower Aspects of Automation and Technical Change. European Conference, 1966.* Paris, France: Organisation for Economic Cooperation and Development, 1966.

Orth, M. N., and Russell, J. F. *Curriculum Development Needs for Vocational Education: New and Changing Occupations.* Columbus: The National Center for Research in Vocational Education, The Ohio State University, 1980.

Osborne, A. *Running Wild: The Next Industrial Revolution.* Berkeley, CA: Osborne/McGraw-Hill, 1979.

Pytlils, E. C.; Landa, D. P.; and Johnson, D. L. *Technology, Change, and Society.* Worcester, MA: Davis Publication, 1978.

Schramm, K. "Business Education for the Future." *International Labour Review* 119 (1980): 115–127.

Schultz, W. H. *The Machinist Shortage.* Photocopied report funded by the Ford Foundation. No publisher given. Author address: 789 Orange Street, New Haven, CT 06511. 1980.

Shaiken, H. "Microprocessors and Labor: Whose Bargaining Chips?" *Technology Review* 83 (1981): 37.

Sniegoski, S. *Technology Assessment and Occupational Education in the Future. Proceedings of a Conference.* Chicago: American Society for Training and Development, 1979.

Stauffer, R. N. "Robotics Training: Tops on the List of Priorities." *Robotics Today* 3 (1981): 2.

Thurow, L. C. "Why Productivity Falls." *Newsweek* 98 (1981): 63.

Uhlig, R. P.; Farber, D. J.; and Bair, J. H. *The Office of the Future.* New York: North Holland Publishing Co., 1979.

SELECTED READINGS

Technology Change Affects Vocational Education

Amara, R. "The Decade Ahead: An Inventory of Resources." *VocEd* 54 (1979): 33-36.

Blair, L. N. *Mechanisms for Aiding Worker Adjustment to Technological Change.* Salt Lake City: Utah University, Human Resources Institute, 1979.

Doggette, J. R., and Crowell, M. R. "Technicians: Where Do We Stand?" *VocEd* 54 (1979): 31-34.

Duvall, J. B. "The Year 2000 ... and Industrial Arts." *Man/Society/Technology* 39 (1980): 18-19.

Fuglsby, G. O. "The Future of Industrial Arts—A Widened Horizon." *Man/Society/Technology* 39 (1978): 22-23.

Gierke, C. D. "Energy Education: Teaching for the Future." *Man/Society/Technology* 37 (1978): 6-9.

Gizychi, R. V.; Weiler, U.; and others. *Consequences of a Broad Introduction of Microprocessors for Educational and Training Policies. Summary.* Frankfurt am Main, Germany: Battelle Institute, 1979.

Hussey, P. "The Impact of Technical Change in the Dairy Industry." *Vocational Training* 1 (1980): 18-19.

Landa, D. P. "What to Do about Technology: The Industrial Arts Educator's Responsibility." *The Journal of Epsilon Pi Tau* 5 (1979): 29-32.

Lee, J. S. "Coping with Technology in the Agricultural Industry." *The Agriculture Education Magazine* 53 (1980): 3.

Leuthold, F. O. 'How Vo-Ag Is a Part of the Adoption of Agricultural Technology." *The Agriculture Education Magazine* 53 (1980): 5-6.

Lundy, L. L. "How the Decline in Productivity Effects [sic] Industrial Arts." *Man/Society/Technology* 37 (1978): 6-8.

Pannell, P. F. "Do Schools Adjust to Changing Job Demands?" *Thrust, the Journal for Employment and Training Professionals* 2 (1980): 105-123.

Snipper, L. P. "Technology Growth Engulfs Education." *American Technical Education Association Journal* 7 (1979): 10-11.

Staerkel, W. M. "Increasing the Individual's 'Cope-ability'." *Co… …ity and Junior College Journal* 50 (1980): 46-51.

Toffler, A. *Learning for Tomorrow: The Role of the Future in Education.* New York: Vintage, 1974.

Whitehouse, J. R. W. "Labour Education: Priority Needs in the 80s." *Labour Education* 42 (1980): 6-14.

Technology Change and Productivity Issues

Almon, C.; Buekler, M. B.; Horowitz, L. M.; and Reimbold, T. C. *1985: Interindustry Forecasts of the American Economy.* Lexington, MA: D.C. Heath, 1974.

American Council of Life Insurance. *The Changing Nature of Work.* Trend Analysis Report 17. Washington, DC: American Council of Life Insurance, 1978.

Donahue, T. R. "The Human Factor in Productivity." *The AFL-CIO American Federationalist* 87 (1980): 13-15.

Herman, A. S. "Productivity Increased in 1978 in Most Industries Measured." *Monthly Labor Review* 103 (1980): 40-43.

Herzberg, F. "Maximizing Work and Minimizing Labor." *Industry Week* (13 October 1981): 61-64.

Margolis, J. "Productivity, Performance, and Professionalism." *Training and Development Journal* (1979): 22-25.

Modic, S. J. "It's Time to Revitalize U.S. Industry." *Industry Week* (12 January 1981): 45-58.

Nadin, M. I. "Sectorial Productivity Slowdown." *American Economic Review* 70 (1980): 349-352.

Neef, A., and Capdevielle, P. "International Comparisons of Productivity and Labor Costs." *Monthly Labor Review* (1980): 32-39.

Norsworthy, J. R.; Herper, M. J.; and Kunze, K. "The Slowdown in Productivity Growth. Analysis of Some Contributing Factors." In *Economic Activity,* edited by A. M. Okun and G. L. Perry. Washington, DC: The Brookings Institute, 1979.

Siegel, R. "Why Has Productivity Slowed Down?" *The Data Resources Review* 8 (1979): 1.59-1.65.

Thurow, L. C. "Why Productivity Falls." *Newsweek* (24 August 1981): 63.

U.S. Congress, Joint Economic Committee. *U.S. Economic Growth from 1976 to 1986: Prospects, Problems, and Patterns.* Volume 1, *Productivity.* Washington, DC: U.S. Government Printing Office, 1976.

Zeimke, R. "HRD's Crucial Role in Productivity Improvement." *Training* 16 (1979): 17, 21, 26, 29.

Technology Change Affects Labor and Employment

Amram, F. M. "Robotics: The Human Touch." *Robotics Today* 3 (1981): 17.

Behuniak, J. A. "Planning the Successful Robot Installaton." *Robotics Today* 3 (1981): 36-37.

Bradbury, F., and Russell, J. *Technology Change and Its Manpower Implications. A Comparative Study of the Chemical and Allied Products Industry in the U.K., U.S., and Japan.* Middlesex, England: Chemical and Allied Products Industry Training Board, 1980.

Cherns, A. B. "Speculations on the Social Effects of New Microelectronics Technology." *International Labour Review* 119 (1980): 705-721.

Cockroft, D. "New Office Technology and Employment." *International Labour Review* 119 (1980): 689-704.

Dymmel, M. D. "Technology in Communications: Its Effect on Labor and Skills." *Monthly Labor Review* 102 (1979): 13-19.

"Effects of New Technologies." *Social and Labour Bulletin* (1979): 336-337.

"Effects of New Technologies." *Social and Labour Bulletin* (1980a): 6-15.

"Effects of New Technologies." *Social and Labour Bulletin* (1980b): 135-156.

Farley, M. "The Chip: Is Time Running Out?" *NATFHE Journal* 5 (1980): 14-17.

Fermoselle, R. "Energy and Jobs for the Future." *VocEd* 55 (1980): 46-49.

Gilchrist, B., and Shenkin, A. "Disappearing Jobs: The Impact of Computers on Employment." *The Futurist* 15 (1981): 44-49.

Myers, C. A. *The Role of the Private Sector in Manpower Development.* Baltimore, MD: John Hopkins Press, 1971.

Norman, C. "The New Industrial Revolution: How Microelectronics May Change the Workplace." *The Futurist* 15 (1981): 30-42.

Organisation for Economic Cooperation and Development. *Manpower Aspects of Automation and Technical Change.* Paris, France: European Conference of the Organisation for Economic Cooperation and Development, 1966.

Schreiber, R. A. "Human Factors: Everybody's Concern." *Robotics Today* 3 (1981): 25.

Shaiken, H. "Microprocessors and Labor: Whose Bargaining Chips?" *Technology Review* 83 (1981). 37.

Thornton, P., and Routledge, C. "Managing the Manpower Aspects of Applying Microelectronics Technology." *International Journal of Manpower* 1 (1980): 7-10.

"When Robots Take Over People's Jobs." *U.S. News and World Report* 90 (1981): 75-77.

Wiener, H. "The Robots Are Here, but Are They Helping?" *Business and Society Review* 35 (1980): 34-38.

Technology Change Affects Occupations

Bureau of Labor Statistics. *1980-1981 Occupational Outlook Handbook.* Washington, DC: U.S. Government Printing Office, 1980.

"Business Education: Its Status, Its Potential, and Its Needs in the 1980s." *Business Education Forum* 35 (1980): 3-11.

Cheatham, W. J. "Technology in Agricultural Mechanization." *Agriculture Education Magazine* 53 (1980): 8-9.

Drucker, P. "Evolution of the Knowledge Worker." In *The Future of Work*, edited by F. Best. Englewood Cliffs, NJ: Prentice-Hall, 1973.

Fagerhaugh, S.; Strauss, A.; Suczek, B.; and Wiener, C. "The Impact of Technology on Patients, Providers, and Care Patterns." *Nursing Outlook* 28 (1980): 666-672.

Iverson, M. J. "Farrier Training—Old Skills, New Technology." *Agriculture Education Magazine* 53 (1980): 11-14.

Lecht, L. A. *Occupational Choices and Training Needs: Prospects for the 1980s.* New York: Praeger, 1977.

Orth, M. N., and Russell, J. F. *Curriculum Development Needs for Vocational Education: New and Changing Occupations.* Columbus: National Center for Research in Vocational Education, The Ohio State University, 1980.

Parnou, J. "An Industry Insider Describes Changes and Choices in Printing Occupations." *Career World* 9 (1981): 3-8.

Schramm, K. "Business Education for the Future." *International Labour Review* 119 (1980): 115-127.

Scnrank, R. "Horse-Collar Blue-Collar Blues." *Harvard Business Review* (May-June 1981): 133-138.

Schreiber, R. A. "Meeting the Demand for Robotics Technicians." *Robotics Today* 3 (1981): 28-29.

"The Food Industry: Innovation and Industrial Structure." *OECD Observer* 106 (1980): 18-23.

Wiegers, G. W., Jr. "Technology in the Agricultural Industry." *The Agriculture Education Magazine* 53 (1980): 4-5.

Technology Change Affects Industry Training

Barker, D. "Industry's Struggle for Skilled Workers." *VocEd* 54 (1979): 26-28.

Franklin, W. H., Jr. "Why Training Fails." *Administrative Management* (1981): 42-43, 72-74.

Grayson, C. T., Jr. "Training's Crucial Role in the Coming Battle to Restore Productivity." *Training* 17 (1980): 82.

Murray, T. J. "Silicon Valley Faces Up to the 'People' Crunch." *Dun's Review* (July 1981): 60–62.

Musick, C. D. *Problems and Issues in Industry-Sponsored Vocational Programs: Implications for Research and Development.* Occasional Paper No. 67. Columbus: National Center for Research in Vocational Education, The Ohio State University, 1980.

Odiorne, G. S. "Training to Be Ready for the 90s." *Training and Development Journal* 34 (1980): 12–20.

Streit, L. D. "Job Competencies for Six Settings. What Skills Do Educational Technologists Need for Job Mobility?" *Instructional Innovator* 26 (1981): 27–28.

"Training for Large-Scale Job Displacement." *Training* 17 (1980): 6, 8, 15.

Technology Transfer

Capriles, R. S. "Technology Transfer and the Industrialists in Latin America." In *Integrated Technology Transfer,* edited by J. Richardson. Mt. Airy, MD: Lomond Publications, 1979.

Hawthorne, E. P. *The Transfer of Technology.* Paris, France: Organisation for Economic Cooperation and Development, 1981.

Nau, H. R. *Technology Transfer and U.S. Foreign Policy.* New York: Praeger, 1976.

Ohio Technology Transfer Organization (OTTO). *Ohio Technology Transfer Organization. Annual Report.* Columbus: The Ohio Board of Regents, 1980.

Richardson, J., ed. *Integrated Technology Transfer.* Mt. Airy, MD: Lomond Publications, 1979.

Zevin, L. Z. "An Integrated Approach to Technology Transfer: Soviet Cooperation with Developing Countries." In *Integrated Technology Transfer,* edited by J. Richardson. Mt. Airy, MD: Lomond Publications, 1979.

Technological Changes and Issues

Abernathy, W. J.; Clark, K. B.; and Kantrow, A. M. "The New Industrial Competition." *Harvard Business Review* (September–October 1981): 68–79.

Ayres, R. U. *Technological Forecasting and Long-Range Planning.* New York: McGraw-Hill, 1969.

Bauer, R. A. *Second Order Consequences: A Methodological Essay on the Impact of Technology.* Cambridge, MA: MIT Press, 1969.

Bell, D. *The Coming Post-Industrial Society.* New York: Basic Books, 1973.

Best, F., ed. *The Future of Work.* Englewood Cliffs, NJ: Prentice-Hall, 1973.

Brzezinski, Z. *Between Two Ages: America's Role in the Technetronic Era.* New York: Viking, 1970.

Bylinsky, G. "A New Industrial Revolution Is on the Way." *Fortune* (5 October 1981): 106–114.

Coates, V. T., and Finn, B. *A Retrospective Technology Assessment: Submarine Telegraphy.* San Francisco: San Francisco Press, 1979.

Committee for Economic Development. *Stimulating Technological Progress.* New York: Committee for Economic Development, Research and Policy Committee, 1980.

Davidson, F. P. "Microengineering: Appropriate Technology on a Planetary Scale." *The Futurist* 14 (1980): 22–28.

Dodd, T. "Robots: The New 'Steel Collar' Workers." *Personnel Journal* (5 September 1981): 688–695.

Douglas, J. D., ed. *The Technological Threat.* Englewood Cliffs, NJ: Prentice-Hall, 1971.

Ellul, J. "Misused Technology: Humanity as a Cog in the Machine." In *The Future of Work*, edited by F. Best. Englewood Cliffs, NJ: Prentice-Hall, 1973.

Ellul, J. *The Technological System.* New York: Continuum, 1980.

Fromm, E. *The Revolution of Hope: Toward a More Humanized Technology.* New York: Harper and Row, 1968.

Gilbreath, K. "Demand of United States Technology." *ATEA Journal* 8 (1980): 8.

Hald, A. P. "Toward the Information-Rich Society." *The Futurist* 15 (1981): 20–24.

Hamrin, R. D. "The Information Economy: Exploiting an Infinite Resource." *The Futurist* 15 (1981): 25–30.

Heilbroner, R. "Work and Technological Priorities: A Historical Perspective." In *The Future of Work*, edited by F. Best. Englewood Cliffs, NJ: Prentice-Hall, 1973.

Jarreau, J. A. "Robots: Carrying a (Welding) Torch for America." *Florida Vocational Journal* (1981): 11–14.

Macioti, M. "Technology and Development: The Historical Experience." In *Integrated Technology Transfer*, edited by J. Richardson. Mt. Airy, MA: Lomond Publications, 1979.

Martino, , P. "A Revolution in Your Hand: Past Is Only Prologue for the Hand-Held Calculator." *The Futurist* 14 (1980): 59–66.

Mayo, J. S. "The Power of Microelectronics." *Technology Review* 83 (1981): 46–54.

Menosky, J. A. "The Gene Machine (Automatic. Everything You Need to Make DNA. Push-Button Controls. Very Fast. Under $30,000)." *Science* 81, no. 2 (1981): 38–41.

Meyer, H. E. "Gamma Rays Have a Glowing Future." *Fortune* (4 May 1981): 201–202, 206–207.

Michael, D. N. *The Unprepared Society: Planning for a Precarious Future.* New York: Harper Colophon Books, 1968.

"Microframe Is Newest Computer on a Chip." *Science* 212 (1981): 527, 528, 530.

Moser, L. J. *The Technology Trap: Survival in a Man-Made Environment.* Chicago: Nelson-Hall, 1979.

National Research Council. *Science and Technology. A Five-Year Outlook.* San Francisco: W. H. Freeman and Co., 1979.

Olson, S. "Prospects for the Automobile. Sputtering toward the Twenty-First Century." *The Futurist* (1980): 27-34.

Osborne, A. *Running Wild: The Next Industrial Revolution.* Berkeley, CA: Osborne/McGraw-Hill, 1979.

Price, M. "Are Robot Users Missing the Boat?" *Industry Week* (2 November 1981): 87, 90.

Pytlik, E. C.; Lauda, D. P.; and Johnson, D. L. *Technology, Change, and Society.* Worcester, MA: Davis Publications, 1978.

Symonds, C. "Technology and Utopia." In *The Future of Work,* edited by F. Best. Englewood Cliffs, NJ: Prentice-Hall, 1973.

Takeuchi, H., and Schmidt, A. H. "New Promise of Computer Graphics." *Harvard Business Review* 58 (January-February 1980): 122-131.

The Techno/Peasant Survival Manual (The Book that De-Mystifies the Technology of the 80s). New York: Bantam Books, 1980.

U.S. Department of Labor, Bureau of Labor Statistics. *Industrial Technology Outlook Reports.* Washington, DC: U.S. Government Printing Office. (Annual)

Vail, H. "The Home Computer Terminal: Transforming the Household of Tomorrow." *Futurist* 14 (1980): 52-58.

TO ORDER ADDITIONAL COPIES OF THIS PUBLICATION USE—	ORDER NUMBER	PRICE
• *Preparing for High Technology: Book 2 Strategies for Change*	RD 230	$ 4.25

TO ORDER RELATED PUBLICATIONS, REFER TO —		
NEW • *Preparing for High Technology: Book 1 Programs That Work*	RD 229	$ 4.95
NEW • *Preparing for High Technology: Book 3 A Guide for Community Colleges*	RD 231	$ 2.75
• *Sharing Resources: Postsecondary Education and Industry Cooperation*	RD 203	$10.00
NEW • *Teacher's Guide to Transferable Skills*	RD 216	$21.00 Set
NEW • *Taking Charge*	RD 217	$19.50 Set
NEW • *Functional Competencies for Adapting to the World of Work*	SN 30	$ 4.50
NEW • *Adaptation to Work: An Exploration of Processes and Outcomes*	SN 31	$ 5.50
• *Vocational Education: A Look Into the Future*	RD 207	$ 5.50

ORDERING INSTRUCTIONS

When ordering, please use order number and title. Orders of $10.00 or less should be prepaid. Make remittance payable to the National Center for Research in Vocational Education. Mail order to

The National Center for Research
in Vocational Education
National Center Publications, Box F
1960 Kenny Road
Columbus, Ohio 43210

Prices listed are in effect at the time of publication of this book. All prices include postage and handling. Prices are subject to change without notice.

Quantity Discounts

Orders of five (5) or more items, as listed by publication order number and title, with a total dollar value for the order of:

$ 50 to $100, the discount is 5%
$101 to $200, the discount is 10%
$201 to $300, the discount is 15%
$301 to $400, the discount is 20%
$401 and above, the discount is 25%

International Orders

All orders, in any amount, from outside the United States and its possessions are to be paid in U S. currency. Additional postage and handling charges may be added for foreign shipments, if necessary.