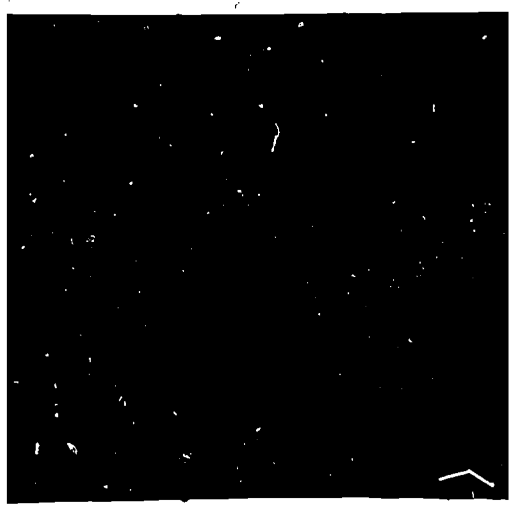

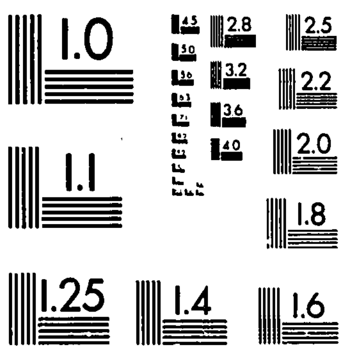

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ABSTRACT

A pressing problem in the United States today is that of employment: how to create enough jobs and, especially, what impact high technology will have on present and future jobs as well as educational need. Some policymakers see high technological industries as the basis for revitalizing the economy. The major challenge to education and training, according to this view, is to prepare adequate numbers of people with required high-level skills and to upgrade the present skill requirements of occupations. In this view, more, better, and more specialized education is needed. In contrast to these persons are those who predict that the effects of high technology on employment will be modest in both the number of jobs created and the skill level required, and that high technology will downgrade skill requirements of existing jobs as well as displace workers already in jobs. Furthermore, the labor force will not require expanded science and mathematics or computer literacy but will be employed in low-level service occupations. According to this view, the relatively small number of workers who will require higher-level skills will be able to obtain them through existing higher educational channels. In our view, what is needed is a comprehensive approach enabling persons to obtain the types of education and training that they need throughout their working lives. Such an approach, called recurrent education, would (1) respond to emerging educational needs, (2) cover a wide range of opportunities, and (3) by establishing a wide range of finance and information, allow persons to undertake a variety of educational and training experiences over a lifetime. Such a system should be a top priority for this country. (KC)

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EDUCATION AND JOBS IN A TECHNOLOGICAL WORLD

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Stanford University

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FOREWORD

Education and Jobs in a Technological World presents the controversial issues of high technology and its implications for jobs and education. It also discusses the impact of high technology on jobs and skill requirements. Finally, it examines the issue of general versus specialized education and recommends an overall, recurrent education system.

This publication is one of nine papers produced by the National Center Clearinghouse's Information Analysis Program in 1984. It is hoped that the analysis of information on topics of interest to the field of vocational education will contribute to improved programming. Papers in the series should be of interest to all vocational and adult educators, including federal and state agency personnel, teacher educators, researchers, administrators, teachers, and support staff.

The profession is indebted to Dr. Henry M. Levin for the scholarship demonstrated in the preparation of this paper. Dr. Levin is Professor of Education and Economics and Director of the Institute for Research on Educational Finance and Governance at Stanford University in California.

L. Gary Lamit, Instructor, Santa Rosa Jr. College; Dan Hull, President, Center for Occupational Research and Development; and Dr. Cathy Ashmore and Tom Conrad of the National Center for Research in Vocational Education contributed to the development of the paper through their reviews of the manuscript. Dr. Russell Rumberger contributed to the development of the paper during its formative stage. Staff on the project included Judy Balogh, Dr. Wesley Budke, and Dr. Judith Samuelson. Ruth Nunley typed the manuscript and Janet Ray served as word processor operator. Editorial assistance was provided by Ruth C. Morley of the Field Services staff.

Robert E. Taylor
Executive Director
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EXECUTIVE SUMMARY

One of the most challenging problems the United States faces today is in the area of employment. Among the discussions surrounding the present and future employment situation, considerable attention is being given to the rising debate on high technology—its potential impact on present and future jobs, skill requirements for high-technology jobs, and high-technology implications for education and training.

This interpretative paper provides information about the high tech debate that will improve policy-making and enhance administrative decision making. The paper will be useful to state and local vocational administrators, policymakers, and interested lay persons.

On one side of the debate are those who see high-technology industries as the basis for revitalizing the economy with new products and new jobs. The major challenge to education and training, according to this view, is to prepare adequate numbers of people with required, high-level skills and to upgrade the present skill requirements of occupations. Recent reports by various national commissions have raised serious questions about the ability of elementary and secondary schools to provide adequately prepared graduates. Most of these reports stress improving the quality and the amount of instruction in mathematics and the sciences and providing all students with computer literacy skills. Likewise, supporters of this side of the high-technology debate suggest providing some form of specialized education for students.

In contrast to this view are those who predict that the effects of high technology on employment will be modest in both the number of jobs created and the skill level required; that high technology will serve to downgrade skill requirements for existing jobs, as well as to displace workers already in jobs. Furthermore, labor force requirements will not revolve around expanded science and mathematics requirements or computer literacy as the vast majority of jobs will be low-level service occupations such as waiters, salesclerks, kitchen helpers, fast-food workers, and cashiers.

According to this view, the relatively small number of workers who will require higher-level skills will be able to obtain them through existing higher educational channels. Also, applied vocational training in secondary schools will not be a desirable approach in a world where job definitions and requirements will be rapidly changing over the lifetime of the worker. Instead, schools should provide students with a strong general education rather than a specialized, technical education. In fact, an education should ensure that individuals have options to enter available occupations at entry levels and provide flexibility to undertake further education and training as needed in order to move into higher-level positions and occupations.

The contention is that the most important missing element from the present system of education and training is a comprehensive approach enabling individuals to obtain the types of education and training that they may need throughout their working lives. Such an approach, called recurrent education, would (1) respond to emerging education and training needs, (2) cover a wide range of education and training opportunities, and (3) by establishing a system of finance and information, allow individuals to undertake a variety of educational and training experiences over a lifetime.

Although components of recurrent education exist already—adult and continuing education courses, correspondence courses, courses delivered by media, and training programs sponsored by trade unions and employers—the construction of an overall, recurrent education system should be of top priority. Such an overall system would tend to use resources more efficiently by providing information, coordination, greater responsiveness to impending shortages or surpluses in the labor market, and a more systematic way of getting new training efforts established.

INTRODUCTION

The challenge of employment in the United States is clearly one of the most serious problems facing our society. In 1983, unemployment rates were in the 9-10 percent range, having fallen from almost 11 percent in 1982 (*Economic Report of the President* 1982, pp. 198-99). Even the most optimistic economic forecasts did not see unemployment going below 7.5 percent in the foreseeable future, despite the fact that the economy was experiencing a rapid recovery from the previous recession. At unemployment rates of 10 percent, some 11 million Americans were officially declared to be unemployed at any one time, and over 22 percent of the labor force was unemployed for at least some part of 1982. It is well known that official measures understate the true unemployment picture by not including those who have given up looking for work and by counting as employed those persons who are working part-time while seeking full-time work (Sorkin 1974). Even after economic recovery, it was expected that 8 to 9 million persons would not have jobs.

As serious as the overall unemployment situation is, the aggregate picture tends to mask the especially catastrophic effects of unemployment for particular segments of the population. For example, the unemployment rate among nonwhites has generally been almost twice the national rate, and unemployment rates for nonwhite teenagers have approached 50 percent in recent years (*Economic Report of the President* 1982, pp. 199, 201). Unemployment rates for teenagers generally have been over 20 percent.

Unfortunately, it is not only the dearth of jobs that is of major concern, but also the types of jobs that are available. The education of the American labor force has been rising at a faster rate than the skill requirements of available jobs (Rumberger 1981). Perhaps 20-50 percent of new college graduates will be taking jobs in occupations that do not require college training depending on the definition of requirements. Further, the pecuniary returns to college-educated workers seem to have declined (Freeman 1976).

Even for those who are fortunate enough to be employed, the types of jobs are often not very desirable. The twentieth century has been characterized by a "deskilling" of work so that jobs at all levels have become more routinized and require fewer judgments and talents of the worker (Braverman 1974). A government-sponsored survey of workers in the early seventies found that work was characterized by

> constant supervision and coercion, lack of variety, monotony, meaningless tasks, and isolation. An increasing number of workers want more autonomy in tackling their tasks, greater opportunities for increasing their skills, rewards that are directly connected to the intrinsic aspects of work, and greater participation in the design of work and formulation of their tasks. (U.S. Department of Health, Education and Welfare 1973, p. 13)

Both the inability of the economy to generate enough jobs and the failure of many available jobs to employ worker skills and talents have become serious social issues.

Deindustrialization and Reindustrialization

In recent years, the issues of employment have been placed in a forum that has arisen on what is sometimes called "industrial policy" (Reich 1983; Harrison and Bluestone 1982; Thurow 1983; Bowles, Gordon, and Weisskopf 1983; Carnoy, Shearer, and Rumberger 1983). These discussions address the loss of America's traditional sources of economic strength, reflected in the decline of production and the employment base in such industries as steel, automobiles, textiles, heavy machinery, and tool and die manufacturing.

All of the participants in this discussion agree that a major restructuring of the U.S. economy is taking place as traditional industries are eroded by foreign competition, recession, and poor management decisions. Now during the eighties, it has become clear that these industries are not likely to regain their previous prominence, and that other countries, including such developing countries as Brazil, South Korea, and Taiwan, have undercut the productive advantages of the United States by taking advantage of more advanced technology, lower wages, and government subsidies.

Beyond recognition of the problem, these analyses differ considerably in their prognoses and policy recommendations. For example, Reich (1983) argues that overcapacity in the production of traditional, basic products, such as steel and automobiles, will result as third world countries join those of the industrialized world in producing these outputs. He suggests that the comparative advantages of the advanced countries will induce them to move to more flexible production modes and products that are custom-tailored to specific applications in electronics, machinery, chemicals, and biotechnology, rather than long production runs of standardized basic products. In his view, this shift will require the adoption of new production methods and greater investments in education and training of the U.S. labor force to meet the new production requirements.

Thurow (1983) recommends an overall public policy that would back economic winners rather than losers. Instead of providing subsidies, tax benefits, and market protection from foreign producers through tariffs and import quotas to firms and industries faced with economic decline, he advocates that public policy provide incentives for firms and industries that are economically promising, competitive, and innovative. His view is that a dynamic economy must provide incentives for success, rather than rescuing its failures that cannot survive domestic and international competition.

Harrison and Bluestone (1982) suggest that much of America's deindustrialization is a consequence of existing government policies providing tax and other incentives for firms that shut down plants and invest in conglomerate mergers and offshore production (foreign operations by U.S. firms). In their view, government policies that support such plant shutdowns and runaway plants ought to be reexamined and new policies should be established to encourage employment stability and maintain domestic production.

Finally, Bowles, Gordon, and Weisskopf (1983) and Carnoy, Shearer, and Rumberger (1983) blame the problems of U.S. economic decline on the concentration of economic power in the United States among multinational corporations and the tendency for government to support the interests of the major corporate monopolies and industries at the expense of societal employment and productivity. They argue for democratic control of investment, employee ownership, worker participation, and community involvement in economic decision making. They suggest greater reliance on a government that addresses the human needs of the nation rather than powerful corporate interests.

High Technology and Employment

Within this larger economic debate on economic policy and employment is one that focuses specifically on high technology. High technology refers to the revolution in the development and use of computers, lasers, communications, information, production technology, biochemistry, and microbiology.

On one side are those who see high-technology industries as the basis for revitalizing the economy with new products and jobs. They see a replacement of the manufacturing society that produces goods with an information society that produces ultrasophisticated services as well as a range of high-technology products in which the United States will have a competitive advantage in world commerce (Toffler 1981). They argue that although the United States will no longer be competitive in the traditional "smokestack" industries, the rising importance of microelectronics, robotics, and biotechnology could enable a shift in employment to these new, expanding industries.

According to this view, the one major obstacle to this future is the capacity of the existing educational and training systems to provide adequate numbers of persons with the high skill levels that will be necessary for the high-technology work force. The assumption underlying this view is that high-technology production will require large numbers of scientists, engineers, and technicians. However, recent reports of national commissions have raised serious questions about the abilities of elementary and secondary schools to provide graduates who are adequately prepared to meet these needs (National Commission on Excellence in Education 1983; Task Force on Education for Economic Growth 1983). Most of these reports place great stress on improving the quality and amount of instruction in mathematics and the sciences as well as providing all students with computer literacy skills. (An exact definition of computer literacy seems to vary from mere exposure to computer concepts and functions, to the learning of at least one programming language, to the mastery of problem-solving techniques using computers.) Some educators also advocate the training of secondary-school students in applied, high-technology skills to prepare them for careers.

The promise of a high-technology future is accepted by virtually all policymakers. However, it is the extent of that future and its meaning for jobs and education that lie at the heart of the debate. At one extreme are those who see high technology driving the economy to unprecedented rates of economic growth and employment. For example, Nolan Bushnell, founder of Atari, predicted at a recent conference on entrepreneurship that "as early as 1987-88, America may see its gross national product booming ahead 15-18 percent annually with 'tremendous labor shortages' that could be solved only by 'opening the southern border'" (Beyers 1983, p. 10). This type of euphoria has led to the recommendation to write off older industries and not take their job loss seriously, as laid-off employees will have substantial numbers of more exciting opportunities in high-technology industries—provided they get the training.

In contrast to this view is one that is somewhat more sobering (Kuttner 1983; Levin and Rumberger 1983). While acknowledging the importance and excitement of the high-technology revolution, this perspective suggests that the effects on employment will be relatively modest in both the numbers of jobs generated and the skill levels required. Advocates of this view argue that a dispassionate examination of labor market trends would suggest an important but far more limited impact of high technology on employment. They suggest the distinct possibilities that microelectronics and robotics will displace workers, even after accounting for the additional employees required to service these new devices (Hunt and Hunt 1983). Furthermore, this effect will be accentuated by the movement of U.S. manufacturers to off shore production sites, especially in Asia. Finally, they assert that a careful assessment of the effects of high technology on existing work and production processes indicates a far greater potential for reducing the skill requirements of jobs than for increasing them.

According to this view, high technology may actually reduce the number of skilled jobs in America, and consequently the challenge of meeting labor force requirements will not revolve around expanded science and mathematics requirements or computer literacy. Most jobs will not require substantial understanding of these domains, since the vast majority of jobs will be low-level service occupations such as waiters, salesclerks, kitchen helpers, fast-food workers, and cashiers. The relatively small number of workers who will require higher level skills will be able to obtain them easily through existing higher-educational channels. Applied vocational training in secondary schools will not be a desirable approach in a world where job definitions and requirements will be rapidly changing over the lifetime of the worker. Instead, schools should be expected to provide a general background in all subjects that will enable students to learn applied skills from the workplace or in postsecondary training. This view, therefore, places much more emphasis on a strong basic education than on providing computer and other applied skills at the elementary and secondary levels.

The remainder of this interpretative paper discusses three major dimensions of the high-technology debate and provides information for state and local administrators and policymakers that can be used to improve policy-making and enhance administrative decisions. The first dimension explores projections of job growth through 1990. The second assesses the likely effects of high technology on displacement and skill requirements of existing jobs. The final section addresses the educational implications of high technology.

OCCUPATIONAL PROJECTIONS

In asking how high technology will affect future jobs, it is essential to differentiate between high-technology occupations and high-technology industries. High-technology industries are considered to be those that produce high-technology services or products, such as telecommunications, microelectronic chips and other components, computers, biotechnology, and robots. Unfortunately, no exact definitions of such industries exist. For example, Tomaskovic-Devey and Miller (1983) used three criteria to define high-technology industries: those with high levels of scientists, engineers, and technicians in their labor forces; those with high levels of investment in research and development; and those based upon the intense concentrations of scientists and technicians and a highly skilled labor force. Depending upon the definition used, different lists of industries and different employment patterns emerge.

It is also important to point out that relatively few jobs in these industries are at scientific or technical levels. For example, only about 20 percent of jobs in microelectronics firms are considered to require scientific or technical skills (Bureau of Labor Statistics 1982). About half of the jobs are in assembly work, while the remainder are largely composed of sales, clerical, warehouse, delivery, and maintenance positions. Likewise, many firms that do not produce high-technology products use such products and require personnel with the skills to utilize them. Thus, many "low-tech" firms, such as textile manufacturers, insurance companies, banks, real estate firms, and farms, utilize computers in their daily operations and require computer personnel—an employment category generally included in high-technology occupations.

For purposes of understanding the employment implications of high technology, it is important to estimate the number of jobs that will emerge in high-technology occupations, not in high-technology industries. Estimates of employment in high-technology industries will vastly overstate the number of high-technology jobs generated by those industries and will omit completely the high-technology jobs created in other industries. Since the ultimate concern of this discussion is with skill and educational requirements for high technology, it is employment in high-technology occupations rather than high-technology industries that should be the focus of concern. In this section projections of occupational employment for the year 1990 will be evaluated.

Job Growth, 1978-90

Without question the best available source of occupational projections is the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor. The BLS has provided projections of occupational employment based on a sophisticated model of economic growth since the sixties. Over the last two decades "the methodology has been continually modified to include greater industrial detail, other models, more rigorous analytical techniques, a more automatic system for processing calculations, and broader coverage" (Oliver 1982, p. 1). Additionally, the methodology incorporates different assumptions about growth in the labor force, economic output, productivity, and aggregate economic growth. Both evaluation by BLS of projections (Carey 1980; Carey and Kasunic 1982; Christy and Horowitz 1979) and external reviews (Goldstein 1983) suggest that the BLS estimates capture the overall occupational trends reasonably well.

BLS has provided projections of employment growth for the 1978-90 period (Carey 1981). (Note that here employment growth refers only to new employment and does not include the replacement of workers in existing jobs.) The following questions concerning these projects can benefit from discussion:

- What proportion of these new positions will be high-technology occupations?
- Which of these new positions will require substantial education and training?

Before presenting the answers, the distinction between fast-growing occupational categories and those that will contribute the most jobs overall during the period of the projections should be made. Failing to make this distinction is often an important source of misunderstanding. If there are relatively few persons in a given occupation, even a very rapid growth rate for that occupation will not add many new jobs to the economy. In contrast, an occupation with large numbers of incumbents and a relatively slow growth rate may contribute very large numbers of new jobs. For example, if an occupational category with 1 million workers grows 10 percent over the period of projections, one hundred thousand new jobs will become available. In contrast, if an occupational category with only one hundred thousand workers grows by 20 percent over the same period, only twenty thousand new jobs will be added to the economy. Thus, the fastest-growing jobs in relative terms (growth rates) may not be the fastest-growing occupational categories in absolute terms. It is the *absolute* number of jobs that emerge in each occupational category that is pertinent to the present quest, not the growth rate.

On the basis of modest growth rates, employment is projected to increase by 22 million (or 23 percent) between 1978 and 1990. The fastest-growing job categories in relative terms—percentage change between 1978 and 1990—include several high-technology areas. Table 1 shows the top twenty occupations in terms of their percentage growth in employment for 1978-90. In contrast with the projected growth of employment of 23 percent over that period, these occupations are projected to grow between 65 and 148 percent.

Six of these top ten occupations are associated with high technology: data processing machine mechanics, computer systems analysts, computer operators, office machine and cash register servicers, computer programmers, and aero astronautic engineers. A common misinterpretation of these results is that most new jobs will be found in these and other high-technology areas.

For example, a recent report of the Education Commission of the States (1983) stated, "Occupational growth throughout the 1980s is projected to expand most rapidly in the higher-skilled, technical occupations" (p. 1). The report details the higher-level skills that all high-school students will need to obtain employment in this high-technology world. Such an interpretation assumes that the most rapidly growing occupations are also those that will provide most of the jobs. But, this is hardly the case.

TABLE 1

TWENTY OCCUPATIONS WITH FASTEST-PROJECTED GROWTH IN EMPLOYMENT, 1978-90

Occupation	Percent Growth in Employment
Data processing machine mechanics	147.6
Paralegal personnel	132.4
Computer systems analysts	107.8
Computer operators	87.9
Office machine and cash register servicers	80.8
Computer programmers	73.6
Aero-astronautic engineers	70.4
Food preparation and service workers, fast-food restaurants	68.8
Employment interviewers	66.6
Tax preparers	64.5
Correction officials and jailers	60.3
Architects	60.2
Dental hygienists	57.9
Physical therapists	57.6
Dental assistants	57.5
Peripheral EDP equipment operators	57.3
Child-care attendants	56.3
Veterinarians	56.1
Travel agents and accommodations appraisers	55.6
Nurses' aides and orderlies	54.6

SOURCE: Carey (1981, p. 48).

Table 2 shows the top twenty occupations in terms of the projected absolute growth in employment. What is most notable about this list is that most of these occupations require very little education or training. For example, the top occupation in absolute employment growth is that of janitors and sextons. Others in the top ten occupations include nurses' aides and orderlies, salesclerks, cashiers, waiters and waitresses, general office clerks, food preparation and service workers for fast-food restaurants, and truck drivers. Only professional nurses and secretaries require some postsecondary education. What is even more remarkable is that no high-technology occupation makes the top twenty, and the only occupation on the entire list that requires a baccalaureate degree is elementary schoolteachers. As a whole, the top twenty occupations in terms of total job growth tend to require very little education and do not include high-technology occupations.

TABLE 2

TWENTY OCCUPATIONS WITH LARGEST ABSOLUTE GROWTH IN EMPLOYMENT, 1978-90

Occupation	Growth in Employment (in thousands)
Janitors and sextons	671.2
Nurses' aides and orderlies	594.0
Salesclerks	590.7
Cashiers	545.5
Waiters/waitresses	531.9
General clerks, office	529.8
Professional nurses	515.8
Food preparation and service workers, fast-food restaurants	491.9
Secretaries	487.8
Truck drivers	437.6
Kitchen helpers	300.6
Elementary schoolteachers	272.8
Typists	262.1
Accountants and auditors	254.2
Helpers, trades	232.5
Blue-collar worker supervisors	221.1
Bookkeepers	219.7
Licensed practical nurses	215.6
Guards and doorkeepers	209.9
Automotive mechanics	205.3

SOURCE: Carey (1981, p. 48).

Although some high-technology occupations are expected to experience rapid growth rates, they will not be major contributors to the overall employment picture between 1978 and 1990. For example, it is expected that jobs for computer systems analysts will increase by over 100 percent in the twelve-year period for a total of two hundred thousand new jobs. But in the same period three times as many new jobs are expected for janitors and sextons. In fact, more new jobs are projected for janitors and sextons than for the top five, fastest-growing occupations combined in table 1. Although one hundred fifty thousand new jobs for computer programmers are expected to emerge between 1978 and 1990, some eight hundred thousand new jobs are expected for fast-food workers and kitchen helpers. In general, low-level and entry-level occupations are expected to provide far greater numbers of jobs than more highly skilled positions. A separate analysis of revised BLS estimates found that only about 7 percent of all new jobs between 1980 and 1990 were expected to be in high-technology occupations.* Although employment in professional and technical occupations is expected to increase by 20 percent for the twelve-year period, this rate of growth is considerably lower than that of the 1960-80 period (Rumberger, forthcoming).

*G. V. Coleman, Office of Education, Washington, D.C. Information from an October, 1982 unpublished memorandum compiled from revised BLS employment estimates, 1980-1990.

How good are BLS estimates? One criticism is that high technology is changing the face of the occupational structure so quickly that BLS projections have failed to take into account the trends. This thought is based upon the assumption that there will be an explosive growth in high-technology personnel that BLS estimates have not anticipated. Whereas it is always difficult to anticipate the impact of technological change, there is no evidence that the BLS model tends systematically to understate the future employment growth of high-technology occupations.

One source of information on this matter is the U.S. Department of Defense (DOD). DOD is especially concerned about projections for technical specialists, since timely development and production of future weapons systems depend heavily on the availability of adequate technical manpower (Dale 1983). Independently developed projections by DOD are remarkably similar to those of the BLS in finding that most job growth in nontechnical areas requires relatively little education (Choate 1983).

Second, a comprehensive evaluation of BLS projections for the 1970-80 period found that, if anything, BLS tended to overstate the impact of technological change on employment growth of high-level occupations. For example, BLS projected a substantially lower growth rate than was actually experienced for seven occupations. None of these was a high-technology or technical occupation; rather, they included roofers, boilermakers, lawyers, cooks, jewelers and watchmakers, dietitians, and guards (Goldstein 1983). In fact, "*overestimates* of the effect of new technology in reducing demand for watch repair work may be one of the factors explaining the greater employment growth for jewelers and watchmakers than was projected" (ibid.).

In contrast, the thirteen occupations for which BLS forecasts were too high included four categories of engineers—an occupation often associated with high technology—aeronautical, chemical, civil, and mechanical (ibid.). The overestimation of growth in such occupations as plasterers, telephone operators, and postal clerks was less related to the unanticipated development of new technologies than to the displacement effects of older ones, such as drywall construction and continuing mechanization of the telephone industry and the post office. Goldstein (1983) concluded that the tendency to overestimate or underestimate the growth of any group of occupations did not exist and that where technological change was a source of error it tended to be in the goods-producing area rather than in services—even though the nonmanufacturing sectors of the economy have been most impacted by high technology. Most importantly, he did not find a single case in which the growth of a high-technology occupation was understated.

There are at least two potential sources of error in BLS forecasts that were not evaluated by Goldstein (1983). The first is the impact of the anticipated increases in the current administration's military budgets that step up the demand for scientific and technical personnel. It has been estimated that about one-quarter of our scientists, engineers, and technical personnel are employed by defense contractors (Dale 1983; DeGrasse 1983, p. 101). The administration's budgetary proposals could increase the demand for engineers, computer scientists, and technical support staff for two reasons. First, the sheer increases anticipated in the military budget from about $228 billion in fiscal year 1982 to $326 billion in fiscal year 1987 (in constant 1982 dollars) would have this effect. Second, the portion of the military budget allocated to weapons systems development and procurement would rise from about 25-50 percent of the total military budget. This means that between 1982 and 1987 the expected rise in weapons development and procurement would rise from less than $60 billion a year to over $160 billion a year. If these plans are actualized, tremendous shortages of certain types of engineers (especially electronic engineers and aeronautical engineers) and other technical specialists could develop (Dale 1983).

Given the political vagaries of the military budget, it is not possible for BLS forecasts to anticipate changes of this magnitude without a clearer picture of future military spending. Thus, the defense budget is clearly a potential element that could upset the projections and raise employment of technical and scientific personnel, including those in high-technology occupations.

A second influence that may not be fully accounted for in BLS estimates is the rapidity with which high-technology production is being shifted to other nations by American manufacturers (Harrison and Bluestone 1982). Semiconductors and microcomputer assemblies are being produced throughout Asia by U.S. firms. The early eighties have demonstrated that such production can be shifted to developing countries more rapidly than had been assumed. For example, Atari announced some seventeen hundred layoffs at the beginning of 1983 in order to transfer production to Taiwan and Hong Kong. Most of the laid-off workers were in the four to five dollars per hour wage range. What was surprising was that the layoffs took place in a plant that was only a few years old and where production was relatively efficient. However, the technology of production had become so automated that workers with very little education and working for lower wages could replace a more educated and costly U.S. work force (even at levels close to minimum wage).

In most of Asia, wages for assembly workers are one dollar or less per hour and the skill requirements for the jobs are so low that the typical worker has not completed primary school. The potential profitability of utilizing these labor forces has stimulated expanded production of all types of high-technology products and components in such places as Singapore, South Korea, Hong Kong, Taiwan, Malaysia, and Indonesia. In 1983, Malaysia was the largest Asian producer of silicon chips outside of Japan, with American manufacturers drawing upon a largely female, little-educated labor force at wages one-fifth or less those of U.S. workers in these same jobs.

The relatively rapid expansion of high-technology production in other nations by American manufacturers may mean not only the loss of assembly jobs, although most of the job creation in these countries is at that level. The various manufacturing facilities that are established offshore also require engineers, technicians, and managers. Although it is uncertain at this stage how extensive this movement will be in the eighties, it appears to be accelerating as the ability to implant advanced technology in developing countries expands and as technology is accommodated to lower-skilled workers.

Summary of High-Technology Employment

Available employment projections suggest that some high-technology occupations will expand at a rapid rate. However, the relatively small size of these occupations means that, even with rapid growth rates they will not contribute very many new jobs to the overall expansion of employment in this country. High-technology occupations are not represented in the top twenty occupations expected to contribute the most new jobs through the eighties. All high-technology occupations collectively are projected to account for about 7 percent of employment growth through 1990. Indeed, most of the job growth will take place in occupations that do not require college degrees, with a remarkable amount of the growth taking place in occupations requiring high school completion or less.

These findings are also supported by analysis of employment data for the seventies. Although more than 19 million jobs were added to the U.S. economy between 1969 and 1979, high-technology occupations accounted for only about 2 percent of them, or four hundred forty thousand jobs (Tamaskovic-Devey and Miller 1983). The employment patterns seemed highly sensitive to the pattern of military expenditures, suggesting that the administration's budget proposals will have a crucial impact on high-technology employment. However, in the absence of a major expansion of defense contracts, the patterns projected for the eighties do not appear to deviate much from those of the seventies. Further, the emerging shifts to increased offshore production may even undermine the present forecasts for high-technology job growth.

Finally, recent data on the hiring trends of college graduates in 1983 do not support the optimistic views suggested by those who see a major expansion in the demand for highly educated workers generated by high technology. Despite a rapidly improving economy in 1983, a major national survey of hiring estimated a 32 percent decline in the recruiting of college graduates in comparison to 1982 (Lindquist 1983). In addition, the number of campus visits made by firms for recruiting nontechnical graduates decreased by 24 percent; recruitment of technical graduates decreased by 39 percent. These declines followed recruiting declines between 1981 and 1982, so the drop in overall recruiting declines between 1981 and 1983 was even more severe. A national survey by the College Placement Council found a similar trend with 51,290 job offers to students graduating with four-year degrees in 1982, but only 33,600 offers to 1983 graduates ("How Economy Is Affecting Job Market" 1983). Although there was some improvement in late 1983, an expanding economy and the rise of high technology have not combined to create a boom market for highly trained labor.

HIGH TECHNOLOGY AND SKILL REQUIREMENTS OF EXISTING JOBS

The first part of the high-technology debate addresses the growth of high-technology occupations. The second part focuses on the impact of high technology on existing jobs. In addition to the new jobs created in high-technology fields, existing employment is affected by high technologies. Computers and various microelectronic applications, along with developments in robotics and biotechnology, are important because of their ability to increase efficiency, productivity, and output capabilities of traditional areas of the economy.

The automotive factory of the future will draw heavily upon programmable, industrial robots (Eaton 1983; Hunt and Hunt 1983). Such robots will be able to work three shifts, be electronically programmable to do a wide range of tasks, and have various types of sensory perception (heat, light, and sound) to guide their activities.

- Microcomputers that are used for "electronic" mail, word processing, electronic filing, and financial accounting and planning are appearing in large numbers in today's offices.
- Computer-aided design and computer-aided manufacturing (CAD/CAM) are being used for the design and implementation of manufacturing processes from the formulation stage to production and for inventory control, purchasing, and quality control.
- At a more mundane level, the use of bar codes and scanning devices—for monitoring purchasing, inventory, and sales—is replacing word processing equipment and cash registers that require manual data entry in wholesale and retail establishments.

As traditional tasks are relegated to sophisticated microcomputers, what happens to the skill requirements of workers in those positions? The popular view has been that as jobs are transformed by high technology, workers will need higher-level skills. This view seems to evolve from the premise that sophisticated equipment requires sophisticated skills. Thus, if workers are to be able to work effectively with computers, they need computer skills. Much of the current demand for computer literacy results from the perceived need to prepare workers for these realities of the "new" workplace.

A contrary view is expressed by those who have carefully looked at the applications of new technologies. They argue that the incentive to employ such technologies is often to reduce skill requirements and labor costs. In other words, investment in new, sophisticated equipment can provide a return only if overall costs of production fall. Thus benefit can be gained if the equipment is used to reduce the number of workers, to increase output for the same work force, or to decrease the skill requirements of the work force so that cheaper labor can be employed. In fact, all three changes may be relevant in any particular case. And, indeed, proponents argue that new technological investment is typically applied to existing production processes to reduce the number of workers and the skills required for production. In this case, high technology would serve to downgrade the skill requirements for existing jobs as well as displacing workers already in those jobs.

This aspect of the debate has significant educational and training implications. Even if high-technology occupations do not dominate the overall expansion of employment, high-technology developments may transform the skill requirements of existing occupations. Accordingly, it will be necessary to consider not only the education and training required for the new technological occupations, but also the changes that will be necessary in existing education and training programs as well.

Historical Background

Before reviewing the effects of high technology on skill requirements of existing jobs, it is useful to examine briefly the historical background of technological change and its effects on workers. Since the beginning of the industrial revolution, employers have sought ways of reducing the skill requirements associated with work. This goal has been accomplished in two ways. First, work processes have been divided and subdivided into a large number of simple, routine tasks that comprise the overall production of a good or service (Marglin 1974). This is a concept that was advocated powerfully by Adam Smith in *The Wealth of Nations* in 1776, and systematized in the scientific management approach of Frederick Taylor at the end of the nineteenth century (Haber 1964). Taylor showed that time and motion studies made it possible to analyze the content of many traditional work procedures requiring highly trained and skilled workers. Through this analysis, the work process was broken down into simple component activities and reconstituted on the basis of individual work tasks that could be learned quickly and required little skill.

Second, the increasing development and application of machines to perform human work have tended to displace human labor in both quantitative and qualitative aspects. From the waterwheel to the steam engine, and especially with the development of the electric motor, it was possible to mechanize the work process (Nelson 1975). In a wide variety of occupations, increasingly sophisticated machines have been applied to replace human skills and judgment (Zimbalist 1979). Both the minute division of labor and mechanization of work have represented traditional methods for reducing the skill requirements associated with jobs and occupations.

Why has the reduction of the skill requirements of jobs been such a pre-occupation for transforming the labor process? A number of reasons have been given. The most prominent, however, is the attempt to reduce production costs and to control the labor process in such a way that labor's power to organize as a class and confront capital is lessened. At the same time, shirking is reduced (Braverman 1974; Edwards 1979; Marglin 1974). Labor costs are reduced by the use of less-skilled labor. In such a situation, workers can be paid lower wages, require less training, and can be easily replaced if they challenge capital. Further, workers know little about the overall work process from the vantage point of their narrowly defined tasks that are reliant upon mechanized processes. Therefore, they find themselves subservient to the knowledge of the owners of capital and their managers who have the power to organize production.

Although it is probably true that technology could have been used to draw more heavily on the skills of workers and to improve the work process from the worker's perspective, this is not where the incentives for production reorganization resided. Rather, the incentives tended toward maximizing profits, pushing the engineering of machinery and work organizations toward the needs of capital rather than worker needs or satisfaction (Noble 1977). These acts were not done necessarily to hurt workers. Rather, the needs of workers did not fit into the equation unless they overlapped with methods for cutting costs and increasing profits. It is this one-sided application of technology that has been historically prominent in the transformation of existing jobs. Decisions on technology have never been democratic ones, but have been determined by decision makers in private and government enterprises who sought the application of technology to reduce labor costs, increase profits, and expand their control of the work force to avoid shirking (Alchian and Demsetz 1972).

It should be acknowledged that most technologies can be used to improve the human dimensions of the work process by increasing the participation of the worker and more fully employing worker skills (Blauner 1964; Jenkins 1974; Levin 1981). Or the technology can be used merely to simply do what is necessary to cut costs or increase managerial control, without concern for the effects on the worker. The more we use technologies to reduce job skill requirements, the less likely we are to realize technology's potential to improve the quality of work life. Instead, exactly the opposite will occur (Blauner 1964; Braverman 1974).

Our humanistic instincts tend to project only those aspects that might enhance the work process. Such an approach emphasizes how high technologies can be used to make jobs more challenging and to eliminate the most menial, routine tasks. But history has not been kind to this vision. What is forgotten is that the incentives for using a technology tend to be driven by the logic of cost cutting and profitability rather than worker needs. This point is overlooked in the wish-fulfilling views of futurists who assume that because technology has a humanistic potential, it will be used in humanistic ways. The potential roles of high technology are limited only by our imagination, but the actual forms taken will depend crucially upon who makes the decisions and to what end.

Prior to the advent of high technology, it was believed that the application of new technologies would raise the skill requirements of workers, that sophisticated equipment would require sophisticated workers, and that menial jobs would be displaced by technology. However, detailed studies of specific manufacturing industries that adopted new technologies in the fifties found exactly the opposite to be true. Bright (1958) observed that the skill requirements of jobs increased during the initial implementation of new technologies, but they declined sharply as the level of mechanization increased:

> There was more evidence that automation has reduced the skill requirements of the operation work force, and occasionally of the entire factory force including the maintenance organization . . . automated machinery tends to require less operator skill after certain levels of mechanization are achieved. It seems that the average worker will master different jobs more quickly and easily in the use of highly automatic machinery. Many so-called key skilled jobs, currently requiring long experience and training will be reduced to easily learned, machine-tending jobs. (pp. 86-7)

Skills and New Technologies

It is interesting to see how this history and the system of incentives for applying technologies to the workplace have been reflected to date in the use of high technology. Perhaps the one major difference from history is that past technological developments had the potential to displace the skills required for physical labor, whereas the advent of low-cost, high-performance microcomputers has the potential for displacing mental labor. Almost any job that can be broken down into a structure that combines information, analysis, and decision making can be transformed into one where the information, the analytic approaches, and decision rules can be programmed onto a microprocessor. In this way, skills required for the traditional job are largely displaced by the computer so that the operator needs little knowledge of the information base, the analytic approach, or the decision rule.

For example, secretaries are being replaced at a very rapid rate by word processors. Traditionally, secretaries had to know the appropriate formats for reports and correspondence, had to have almost letter-perfect typing skills, and needed strong spelling skills and a basic understanding of grammatical usage. Today word processors can correct typing errors automatically, so letter-perfect typing and strong spelling skills are no longer required. Also, word processing programs can be used for formating different types of documents and for grammatical reviews. The result is that many of the traditional functions of the secretary have been replaced by the machine. Moreover, the shift from a typewriter to a word processor requires relatively little training. According to one of the major suppliers of temporary help, typists who lack a background in word processing can be trained in one day of intensive instruction. Orientation for using specific word processing equipment or software is provided in even less time.

A second area in which computers are transforming skill requirements is bookkeeping, accounting, and financial analysis. Traditionally, bookkeepers required substantial training in appropriate data entry of specific transactions. Accountants required a background in methods of utilizing the data to provide specific cost analyses, profit and loss statements, balance sheets of assets and liabilities, and tax liabilities. Business analysts needed special training in using the data for making investment, pricing, and other decisions. However, the development of financial spreadsheet programs and other accounting software has made it possible for persons with little or no specific training in these areas to enter transactions, monitor and project income and expenditures, and handle accounts receivable and payable. Since the data are stored in a variety of usable formats, specific financial analyses can be developed rapidly, often on the basis of a few simple keystrokes. Relatively simple instructions for data entry enable the user to carry out other types of sophisticated analyses, such as budget projections and potential investment profitability decisions.

Whereas technology has provided a powerful tool for managers and executives, employment consequences are extensive and far-reaching. They include a reduction in the number of bookkeepers, accountants, and financial analysts and their replacement by persons responsible for data entry and the mastery of a few simple routines for preparing reports and analyses. To a large degree, the skills of the former, trained personnel are replicated by the accounting and financial software, just as secretarial skills are displaced by the software capabilities of word processing.

Legal research is another area that has been impacted heavily by high technology. Much of legal training is oriented toward helping lawyers chart strategies for legal actions based upon judicial precedent. Such endeavor requires the ability to investigate systematically the decisions and reasoning of other cases, a task that lawyers traditionally spent many hours doing. Now through electronic data retrieval, legal aides can select "key words" and quickly search thousands of cases to find pertinent ones. The nature, strategies, and outcomes of previous cases are summarized in computer memories and pertinent cases can be identified with rapid computer searches for further scrutiny. In general, an individual with a baccalaureate degree or less can serve as a legal researcher, enabling the lawyer to review the results of the search in order to set out a strategy.

Law firms are not only able to substitute legal aides using computers in tasks previously done by lawyers, with the assistance of computers, but they are also able to displace some of the need for lawyers and secretaries by using word processors in preparing legal documents. Much of the wording of such documents can be stored on disks so that additions or deletions need only to be made to prepare a finished document addressing a particular need.

The field of computer programming has also been transformed by the computer revolution. Not only were earlier computers larger, more expensive, and less capable than today's computers, they were far more difficult and cumbersome to program (Kraft 1977; Greenbaum 1979). The sophistication of computers and computer software has become a powerful ally, enabling programmers to accomplish results superior to those of their predecessors, with far less training than was once required. Originally, programming required knowledge of plugboard circuits and high-level machine languages. Over time, the average practitioner was able to shift to assembler languages and scientific, user-oriented programming languages. Today, the average programmer uses relatively simple, user-friendly programming languages, such as BASIC and PASCAL, and packaged software programs that require far less skill than previously needed.

Especially important is the fact that contemporary programmers are assisted by the powerful software that provides general solutions to applied problems. Many programmers need to know only enough to be able to apply the software capabilities to the particular problem being addressed. The vast majority of today's programmers are far removed from the frontier of the art unlike those pioneers in the earlier stages of computing. Most simply need to have working knowledge of relatively simple and user-friendly languages, as well as menu-prompted application packages.

A similar pattern has characterized computer repair. In the early days, computer repair personnel needed to have an understanding of circuit logic, computer components, and the application of standard electronic equipment in order to diagnose malfunctions. Today, computer diagnosis is done largely by applying sophisticated, diagnostic equipment that identifies the malfunctioning circuits or components. The power of the diagnostic equipment and the simplicity of identifying and replacing components have reduced drastically the skills required for computer repair.

This brings up the more general question of whether persons using computers need to have computer skills. This is especially relevant in view of the prediction that half of the work force will be using electronic terminals by 1990 (Giuliano 1982). Evidence suggests that the vast majority of such users need no special knowledge of computers. For example, sales, purchasing, and inventory functions are often computerized so that purchased products are recorded by a scanning device which the cashier passes over a bar code and incoming goods are recorded by a warehouse person using a similar device. Obviously, such persons do not need knowledge of computers even though they are using computerized technology. Their jobs require less skill than the traditional cashier or receiving clerk who had to operate a cash register or record shipments manually.

No special computer skills are needed for such office work as word processing, electronic filing, computerized mailing, and financial spreadsheet utilization—four of the major applications for persons using computers. The point is that computer use does not require programming or other computer skills. Most applications are user friendly, so the operator need only follow a routine set of directions. In fact, Apple Computer Company advertises that a person with no previous exposure to computers can utilize productively the six major functions of its most sophisticated office computer, the Lisa model, with only twenty minutes of instruction. Even many keyboard functions are becoming obsolete with the introduction of more sophisticated software and various mechanical devices such as the "mouse" that is used to choose functions on the Apple Lisa. This simplified mode of operation is clearly the direction of the future.

A related issue is the degree to which entire classes of skilled workers will be displaced or severely reduced in numbers as their jobs are taken by robots and microcomputers. It has been estimated that robots could displace up to 3 million operative manufacturing jobs in the next two decades and potentially eliminate all 8 million operative positions—currently 8 percent of the work force—by the year 2025 (Ayres and Miller 1982). Estimates suggest that 15-20 percent of welders and 27-37 percent of production painters will be displaced by industrial robots in the automobile industry by 1990 (Hunt and Hunt 1983, pp. 169-70). Although it is clear that new jobs will emerge in robot production, operation, and maintenance, more jobs are expected to be lost than replaced through new occupations (ibid.).

Most new jobs are expected to be robotic technicians requiring postsecondary training, but it is expected that a surplus rather than a shortage of such persons will be created as postsecondary institutions expand their training programs for this specialty too rapidly (ibid., 171-72). A bright spot in this picture is the expectation that in the short run many new jobs will require higher-level skills than the unskilled and semiskilled ones that they displace. At the present developmental stage, about 40 percent of employment by robotic manufacturers is at the engineering and technician level. This proportion is likely to decline substantially as mass production and implementation of robots is established.

Indeed, the main impact of robotics is expected to take place after 1990. The displacement effects of programmable robots and the longer-run effect of skills changes will not be discernible until that time (Turner 1983). The longer-run projections are even more pessimistic concerning both employment and skill levels of robots and other programmable technologies (Ayres and Miller 1982; Nilsson 1983). Bright (1958) typically found that skill requirements associated with new technologies tended to rise in the short run before declining drastically as the technologies were adapted to routine utilization.

In similar fashion, automatic teller machines (ATM) are replacing bank tellers at very rapid rates. According to an industry newsletter, almost thirty eight thousand of these machines are in use, with expansion occurring at about thirteen thousand a year (Kershner 1983). Each machine replaces two tellers and the savings in salaries make it possible to recover the cost of each machine in one to three years of normal use. The widespread use of computer-aided design and manufacturing (CAD/CAM) may virtually eliminate the occupation of drafters in the not-too-distant future, a potential loss of three hundred thousand skilled positions (Gunn 1982). The potential of high technology to displace jobs more generally has been singled out by Nobel economist Wassily Leontief as one of the major economic challenges of our time (Leontief 1982).

In summary, it is clear that the applications of high technology can be used to improve the quality of working life and increase (or reduce) the use of worker skills. Walton (1982) suggests that social choices in the application of information technology can determine the outcome. But applications of technology in the workplace, as well as present evidence suggest that the general impact of these technologies is to simplify and routinize work tasks further and thereby reduce opportunities for worker individuality and judgment. While there may be some exceptions to this pattern, they are likely to be outweighed by current data showing that those occupations with the largest employment levels (i.e., clerical and service jobs) are those that are most affected by the trend towards deskilling.

Many technical positions in rapidly growing occupational categories, such as computer programming and repair, are also affected by high-technology usages. Moreover, worker job displacement and downgraded skill requirements for most of the new positions will undermine employment generally. Finally, capabilities in the field of artificial intelligence to develop mechanical replacement for human labor are considered by some experts to be barely tapped at present (Nilsson 1983). Over the long term, they see far more serious implications arising for the future distribution of work and income in a society where there loom severe shortages of jobs at almost all levels.

IMPLICATIONS FOR EDUCATION AND TRAINING

The high-technology debate revolves essentially around the numbers and types of jobs that will be created by high technology, as well as the impact of technology on existing jobs. There are those people who argue that high-technology occupations will dominate future growth in occupational employment and raise skill requirements in existing occupations. Others argue that high-technology occupations will account for a relatively small part of total employment growth and that the impact of high technology on existing jobs will be a reduction in skill requirements.

Clearly, the focus of this debate has profound implications for education. If occupational growth for skilled positions is rising, it warrants deep concern about the capability of the nation's educational and training systems to meet further demands. If this is not the case, however, we must take care lest the educational and training system prepare students for an unrealistic future. But at the same time, we must continue to search for ways of improving education and training, even in the absence of a boom in occupations that will require high skill levels.

Although many policymakers continue to look toward growth in high-technology jobs as the solution to the employment problem in the United States, available evidence does not support their optimism. Neither does it support the view that the impact of these technologies upon existing occupations will be to upgrade their education and training requirements.

Evidence suggests a number of conclusions that have consequences for education and training.

- Most growth in occupational employment is projected to take place in low-level service occupations rather than in occupations requiring strong technical training. Even within high-technology firms, the vast majority of jobs are in assembly, clerical, and service occupations.

- Many existing jobs requiring lower- and middle-level skills are likely to be eliminated by the application of new technologies, and some jobs at high levels will also be affected.

- Although new jobs will emerge in conjunction with the new technologies, they are not likely to equal the number that are lost. Savings in labor costs are a major incentive for adopting the new approaches.

- In the short run, some of the new jobs will require higher-level skills than those that they replace. In the longer run, it appears that even these jobs will be downgraded in skill requirements in the same manner as much computer programming and computer operation have become simplified and routinized.

- Two major factors that could upset these projections are the extent of increase in the military budget and the shift of production to offshore sites. Rapid increases in the military budget and in weapons system development and procurement could increase substantially the numbers of scientific and technical personnel employed by firms. Rapid shifts of production from domestic to offshore sites could reduce employment for lower-level technical positions, as well as assembly and clerical positions.

- The applications of new technologies will have a far greater impact in reducing skill requirements of jobs than raising them.

- Over the lifetime of workers many changes may occur in the nature of their jobs as applied technologies advance more rapidly than they have historically. This suggests that workers will need to be retrained more often, and not necessarily with higher-level skills as much as with different skills.

Educational and Training Policies

A number of recent reports by national commissions are premised on the view that America's standing in the world competition for high technology will be handicapped by a general shortage of adequately trained workers (National Commission on Excellence in Education 1983; Task Force on Education for Economic Growth 1983). Without presenting evidence on the changing job structure, these reports *assume* that skill requirements of the workplace are being drastically upgraded. At the same time, they identify major areas of weakness in American education, such as declining test scores, low participation in science and mathematics courses, and relatively short school days and annual school sessions. When these weaknesses are combined with the assumed future scenario regarding rapid increases in skill requirements of jobs, these commissions sound an alarm about the adequacy of the American educational system to meet these new demands of the economy.

Unfortunately, their view is based upon ostensibly false premises regarding the nature of the job market. Further, it ignores other legitimate grounds for concern about American education unrelated to the future size and skill of the labor force. A host of controversial political, economic, and social issues require citizen analysis, debate, and participation. If many of our citizens are limited by inadequate education from participating in this process, they relinquish their influence over policies that will have profound future impact on their lives and on their country.

In addition, educational inadequacies in both labor market skills and citizenship are essentially concentrated among persons from low-income and minority backgrounds, a point overlooked in the national reports. To a large degree the distribution of educational opportunities and equality is at issue. Even if there is no crisis in the aggregate numbers of trained persons available in the labor market, the inadequate preparation and access of minorities and the disadvantaged will limit severely their economic, political, and social participation. More likely they will be unemployed or relegated to low-paying, dead-end jobs with no hope for upward mobility, and their political participation will also be limited.

The apparent inadequacy of the present educational system to provide a useful foundation for general citizenship, as well as the concentration of failure among the disadvantaged and racial and ethnic minorities, should not be dismissed lightly. This concern has been obscured by assertions that the principal educational dilemma is the pending shortage of skills for future labor markets. But these reports have not documented their claims. However, it is possible to agree with many of the recommendations of these documents for raising educational standards without accepting the underlying assumptions of skill shortages. In other words, raising educational standards and ensuring minimal standards for all children is a desirable goal for improving citizen participation and the economic, social, and political participation of disadvantaged and minority citizens.

In addition to the citizenship and equality concerns for elementary and secondary schools, other pertinent concerns about future labor markets should be emphasized. First, we are entering a period of rapid technological change in which both entry-level and high-skill positions are being transformed, often in unpredictable ways. For example, a survey of skill needs at a technician level anticipated by employers for the state of Texas identified the category of draftsperson as the one with the greatest technical skill shortage (Galambros 1983). Whereas this may have been true at the time of the survey, both the hardware and software associated with computer-assisted design (CAD) have advanced to the point where they are rapidly displacing draftspersons (Gunn 1982). It is likely that even without training additional drafting personnel, substantial long-term surpluses are on the horizon.

At the unskilled level, jobs in sales, inventory, and purchasing areas, such as data entry on keyboards, are being replaced by data entry with scanning devices and bar codes. Although this job category burgeoned in the last decade when computer-based wholesale and retail trade proliferated, already it is being displaced by a more advanced technology.

Second, we cannot predict accurately which jobs will be available to any particular person over a career of four to five decades, nor can we predict which particular job or combination of jobs an individual will actually obtain among those that are available. Given these circumstances, education must be provided that will allow individuals the option of starting at entry level in the available occupations, and of undertaking education and training as needed in order to move into higher-level occupations. Thus, in order for elementary and secondary education to meet future labor market conditions, strong general skills to enhance versatility and the ability to benefit from further training should be stressed—rather than narrow, labor market preparation. This inclination toward general preparation is consistent with a concern for citizenship and equality. A strong general education for all students, while providing the flexibility required to undertake further training and to adapt to technical change, provides the basis for widespread economic, political, and social participation.

Within the labor market context, this basic foundation should emphasize the knowledge and skills required to learn and perform in a changing work environment. Included should be skills in logic, analytic reasoning, scientific knowledge, and communication, with emphases on reading, writing, speaking, listening, interpretation of written or spoken material, and proficiency in one or more foreign languages. These skills can be acquired largely through minimum course requirements in science, mathematics, English, foreign languages, the arts, and social studies. Especially important is the way that these courses are taught. Emphasizing components of problem solving, analytic reasoning, reading, and writing across all curriculum boundaries, rather than limiting instruction in specific courses, should be required. This kind of background ensures access to productive study at the postsecondary level or to entry-level jobs and potential job mobility.

Vocational Education for High Technology

Obviously, the basic foundation would have broad implications for vocational preparation in qualifying persons for entry-level positions and on-the-job training, or for further study at the postsecondary level, to prepare for higher-level careers. However, this approach does not support narrow vocational preparation at the secondary level for a single job or occupation. The reason for such limitation is the rapidly changing nature of jobs for which secondary-school training would prepare individuals. It is those jobs at the semiskilled and skilled levels that are most susceptible to technological change. Unskilled jobs, on the other hand, require virtually no applied vocational preparation outside of the jobs themselves. For these reasons, specific or narrow vocational preparation should more appropriately be assigned to the training programs of firms and to postsecondary institutions.

Exposure to computers and their capabilities is perfectly consistent with the basic foundation—given the widespread prevalence of computers at all levels of society. But it is not necessary to teach students computer programming as an end in itself. Most students will not use programming skills in their careers, and programming languages and their use will change rapidly in the foreseeable future. Students might be exposed to the concept of using computers as learning tools to solve mathematics and science problems, as an aid in understanding art and design, and to assist them with writing through word processing programs. Computer literacy should not be viewed as an end in itself, but as a way of integrating an important dimension of modern technology into the overall, basic foundation of the school. This view is consistent with that of computer pioneer Joseph Weizenbaum (1983) who fears educational obsession with computer literacy may do more harm than good.

Why cannot vocational training and the general educational foundation necessary for further learning be combined? Granted, the goal of the comprehensive high school was to provide access to both types of learning. But in addition to the danger of rapid obsolescence of applied training is the problem of a limited amount of time in the school curriculum. When students take courses in one area, they lose instruction in other areas. The goals of a strong general education and those of narrow vocational training are sufficiently independent and there is little evidence that they can be provided in the same curriculum.

The strongest case for applied vocational training at the secondary level would seem to be that the intrinsic interest of the student in tangible job training will keep many youth in school who might otherwise become dropouts (Grass and Shea 1979; Lewis and Mertens 1981; National Academy of Sciences 1983). However, given the epoch of school reforms that we are entering, it would seem to make more sense to upgrade the quality and vitality of instruction to improve the attractiveness of all forms of schooling. At the same time, access to supervised work experience—which is an important strength of secondary-level vocational education—might be expanded to incorporate all secondary students. A major challenge for America's secondary schools is to make schooling an engaging activity that provides greater intrinsic motivation while providing access to supervised work experience. It is hoped that these lessons from vocational education can be transferred successfully to other secondary schools.

The basic educational foundation is a goal that must be sought for all youth. Given the substantial differences in learning advantages and backgrounds of youth, this goal is an ambitious one. But it is far more attainable than the present situation might imply, where unequal resources, tracking, and low expectations condition the outcome. Applied vocational training would build on this basic foundation in two forms.

First, postsecondary educational and training institutions would capitalize on the better schooling of the young to prepare them for specific careers. Much of this career preparation would take place at the community college level and among proprietary training institutes, offering programs highly responsive to the local and regional job market. Such institutions would also anticipate major changes in occupational employment patterns in order to accommodate the expansion of new careers and the decline of older ones. Presumably, they would build on an improved system of information feedback from current and prospective employers made possible by advanced communication technologies (Lynton 1983).

Second, a substantial portion of the training will continue to take place within the individual firm. Carnevale and Goldstein (1983) estimate that in-house and outside training cost employers

$20-30 billion in 1981, and there were as many employees receiving such training as students enrolled in postsecondary educational institutions. It is clear that employers will continue to take substantial responsibility for both job training and retraining. Much of the training that will take place will consist of relatively short courses, measured in hours or days, to orient workers to their tasks. Retraining within the firm will typically consist of teaching different skills rather than higher-level skills. (In contrast, postsecondary educational institutions will stress the upgrading of skills.) For example, persons using word processors need to have applied knowledge of that equipment in order to use the technology effectively. This does not mean that there is an upgrading in skills. Indeed, as asserted previously, word processors do not require letter-perfect typing or strong spelling skills since technology can easily compensate for shortcomings in these areas.

Constructing a System of Recurrent Education

The most important element missing from the present system of education and training is a comprehensive approach enabling individuals to obtain the types of education and training they will need during their working lives. This approach is known as recurrent education, because education would take place in a recurring pattern with work and leisure. Although various dimensions of such a system can be found in adult education, continuing education, job training programs, and correspondence courses, as yet, there is no overall structure that would provide the incentives for a responsive and flexible approach to recurrent education. Clearly, vocational education is a central goal of recurrent education in both training and retraining.

An overall system of recurrent education would have the following features:

- It would be responsive to emerging educational and training needs in the sense that individuals facing unemployment or declining employment prospects, or those seeking upward mobility would have the incentives and opportunities to undertake appropriate training or retraining.

- It would be flexible in the sense that a wide range of educational and training opportunities would be covered, such as apprenticeships, on-the-job training, and formal instruction in postsecondary institutions.

- It would be comprehensive in establishing a system of finance and information that would enable individuals to undertake a variety of different educational or training experiences over a lifetime, according to the needs of employers and workers. (Levin 1977)

Presently, there is no overall approach to recurrent education in the United States, although a variety of components to such an approach do exist. For example, school districts, colleges, and universities often sponsor extensive programs of adult and continuing education courses, correspondence courses, and courses delivered by television and other media; trade unions and employers sponsor extensive training programs; and various levels of the government offer training and retraining programs. However, these programs often overlap and have different eligibility standards for participation. No overall source of available information exists and for the most part, offerings are uncoordinated and piecemeal due to idiosyncratic funding sources and methods.

A recurrent educational approach would tend to use overall resources more efficiently by providing information, coordination, greater responsiveness to impending shortages or surpluses in the labor market, and a more systematic way of establishing new training efforts. The latter has become an especially high priority as the number of youth entering the labor force declines and a greater emphasis must be placed on retraining the experienced labor force at a time of rapid technological change (U.S. Congress 1983, Chap. 3). However, proposals for constructing an overall system of recurrent education are only at the discussion stage (Levin and Schutze 1983). Some advocates would build on the use of postsecondary entitlements that could be used by individuals to finance education or training over their lifetimes, in contrast to the present system of finance that stresses support for immediate postsecondary education prior to entering the labor force. Others would draw upon the West European experience of educational sabbaticals financed through the tax system. No matter how constructed, a crucial priority for the future is the formation and development of an overall system of recurrent education that will allow for the efficient and responsive retraining of the labor force.

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