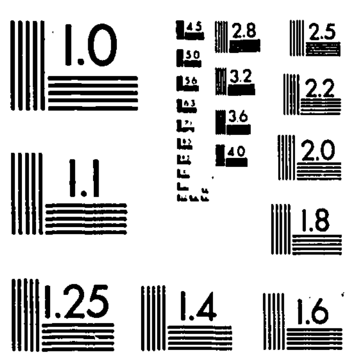

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ABSTRACT

Today, this country is facing awesome challenges. Technology is changing all aspects of life, while work force requirements shift rapidly, swelling the numbers of workers who need to be retrained. At the same time, information technologies are creating changes in the automated office. Higher-level literacy is required for most workers in this sector. As the economy moves from an industrial to an information base, the mass educational approach designed to turn out productive workers for industry is no longer deemed appropriate. Rather, education for the future must be improved; not only must schools reemphasize the basics, they must expand the traditional curriculum to include communications, higher-level problem-solving skills, and scientific and technological literacy. Whereas only 7 percent of this country's new jobs will be in high-technology occupations, programs to train workers for these jobs must be designed and implemented quickly if the United States is to compete in the international marketplace of the new global economy. Educators at all levels should cooperate to provide their students with higher levels of mathematics, language, science, and computer literacy skills, along with critical thinking and reasoning skills. (This paper provides information about and examples of the types of programs needed to prepare persons for the new technological jobs that are emerging.) (KC)

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EDUCATION AND TRAINING FOR A TECHNOLOGICAL WORLD

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Indiana State University

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The National Center for Research in Vocational Education
The Ohio State University
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1984

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FOREWORD

Education and Training for a Technological World presents a comprehensive view of the effects of current technological innovation on life, work, and schooling. A discussion of the way in which individuals prepare for technological occupations is accompanied by information about and examples of the education needed to enter such preparatory programs.

This paper 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. C. Dale Lemons for the scholarship demonstrated in the preparation of this paper. Dr. Lemons is Assistant to the Vice-President for Academic Affairs at Indiana State University. Twenty-eight years of teaching, research, and administration in industrial arts, vocational and technology education, and teacher education contribute to his expertise in this field.

David E. Baker of the Illinois State Chamber of Commerce, Celeste Billhartz of the Summit County Ohio Board of Education, and Dr. Robert Bhaerman and Karen Kimmel-Boyle of the National Center for Research in Vocational Education contributed to the development of the paper through their reviews of the manuscript. 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 Morley of the Field Services staff.

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

EXECUTIVE SUMMARY

Dramatic technological changes are affecting every segment of society. Just as the agrarian age gave way to the industrial era, so is the latter being forced to yield to the information age. Despite the early warnings of some of America's great thinkers, the United States has remained essentially unprepared for the challenges presented by this new era. This paper is intended to provide local vocational education administrators with an awareness of the magnitude of this challenge, to stimulate interest among them in revising programs to meet the challenge, and to provide them with information about programs. A discussion of the importance of technology education and descriptions of programs are presented. Resources useful for obtaining more information about program planning and installation are included.

Today this country is facing awesome challenges. Technology is altering all social institutions; jobs and careers are increasingly transitory; the educational system struggles to prepare and maintain an adequate level of general and vocational training for our citizens; uncertainty prevails as to what kind of education is needed for living and working in today's increasingly technological, knowledge-intensive economy.

Adding to the confusion are rapid shifts in work force requirements. Dislocation among today's industrial workers will continue to swell the numbers of these workers who become candidates for retraining. Many workers formerly employed in traditional "smokestack" industries do not have the skills to compete in emerging high-technology occupational areas. Programmable, automated manufacturing technologies have, at the same time, taken their former jobs and presented them with new ones that they are unprepared to handle. Their manipulative skills are no longer needed, and, instead, mental skills in planning, scheduling, and programming are required.

Information technologies are creating a similar change in the automated office. Higher-level literacy is required for most workers in this sector, and here too, job titles change as workers' former jobs are restructured. Some disagreement exists on this point, but the belief that high technology will require more sophisticated skills than those needed in the past is fairly widely accepted. This belief is based on the two following assumptions:

- High technology will upgrade skill requirements of existing jobs because of increasingly sophisticated equipment.
- High technology will favor professional and technical level jobs.

The contrary belief—that a high-technology economy will require even less sophisticated job skills—is based on the following different assumptions:

- Most new jobs will not be in high-technology occupations.
- The application of high technology in existing jobs will not require a vast upgrading of the skills of the work force.

These assumptions are supported by the assertion that none of the twenty occupations projected to have the most new openings fall in the high-technology category.

As the economy moves from an industrial to an information base, the mass education approach designed to turn out productive workers for industry is no longer deemed appropriate. The system that promoted punctuality, obedience, and tolerance for repetitious work is now asked to re-create economic vitality. A report card on education from any of several special commissions that recently studied American schools would not present a favorable picture of the schools' ability to attain this objective. The consensus of these findings is that education in and for the future must be improved. Not only must schools reemphasize the basics, they must expand the traditional three Rs to include communication, higher-level problem-solving skills, and scientific and technological literacy.

- Technology and technological development affect every aspect of our society—on a local, state, national, and international level.
- Technological development and educational development are closely related.
- Economic development and technological development are closely related.
- The United States competes economically with other technologically developing countries.
- The United States' educational supremacy is being lost to other countries.
- The United States' technological supremacy is eroding.
- High technology has created a dichotomy in the work force.
- Employment in high-technology occupations requires a higher level of education and training than industrial occupations of the past.
- Preparation for high-technology occupations can be provided by many different agencies or institutions, most of which offer postsecondary-level training.
- The role of elementary and secondary educational institutions is to prepare individuals for satisfactory living in a technological world, including for many a readiness to benefit from preparatory programs in high-technology occupations.

Whereas only 7 percent of this country's new jobs will be in high-technology occupations, programs to train workers for these jobs must be designed and implemented quickly if the United States is to compete in the international marketplace of the new global economy. Engineers and technicians are trained for high-technology occupations primarily by four-year and two-year colleges, respectively. Some training for high-technology equipment maintenance technicians is being provided at the secondary level. Business, industry, and labor are also providing a significant amount of training and retraining.

The education required to prepare individuals for postsecondary education and training for high-technology occupations is clearly composed of mathematics, language, science, and computer literacy, along with critical thinking and reasoning skills. Schools at all levels are faced by the challenge of providing these skills. Educators need to study ways to improve cooperation and increase articulation among programs so as to provide these skills.

INTRODUCTION

Change is an inevitable fact of modern society, but what is unpredictable is the rate and direction of that change. The world is presently undergoing significant transformations brought about by rapidly advancing technological development. No segment of our society remains untouched by its influence. Technological and economic changes have far-reaching impact on the workplace, the work force, and consequently, on education. Permanent worker displacement, temporary unemployment, and needed preparation for future occupations place new and demanding requirements on general and vocational education.

Just as the agrarian society gave way to an industrial one, so is the industrial era being rapidly replaced by a technological age. What title to bestow on the new era seems to be a matter for discussion. But whether a society is called "technological," "postindustrial," "superindustrial," or "informational" is not as important as the changes being wrought and the ability or inability of our society to cope with them.

Toffler (1980a) stated it in *The Third Wave* as follows:

> A new civilization is emerging in our lives, and blind men everywhere are trying to suppress it. This new civilization brings with it new family styles; changing ways of working, loving, and living; a new economy; new political conflicts; and beyond all this an altered consciousness as well. Pieces of this new civilization exist today. Millions are already attuning their lives to the rhythms of tomorrow. Others, terrified of the future, are engaged in a desperate, futile flight into the past and are trying to restore the dying world that gave them birth. (p. 25)

Despite admonitions by Toffler (1970) in *Future Shock*, Bell (1978) in *The Coming of Post-Industrial Society: A Venture in Social Forecasting*, and others, the United States has remained essentially unprepared for the challenges of this technological age. It appears that only when consciousness is raised by such events as the severe economic recession of the past few years that action is precipitated. As workers are displaced from jobs, American industries lose their customers in international markets, and the country's leadership role in technological innovation begins to erode. Next, the cry comes forth for government, education, and industry to do something about it.

The economic impact from the build-up of foreign technology has been severe. One indication of this change is that Japan now exports about $5 billion more in high-technology products to the United States than it imports from us ("U.S. Firms Must Adapt Faster" 1983). Recognition of this shift has given rise to a widespread sense of urgency. As the National Commission on Excellence in Education (1983) stated, "Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world" (p. 5).

Today this country is facing awesome challenges. Technology is altering all social institutions; jobs and careers are increasingly transitory; the educational system struggles to prepare and

maintain an adequate level of general and vocational training for our citizens; uncertainty prevails as to what kind of education is needed for living and working in today's increasingly technological, knowledge-intensive economy.

Purpose

The purposes of this paper are to provide local vocational and general education administrators with an awareness of the challenges presented by a highly technological society, to stimulate interest among them in revising programs to meet these challenges, and to provide them with information about programs. A discussion of the importance of technology education and descriptions of programs are presented. Resources useful for obtaining more information about planning and installing programs are included.

Technology education refers to singular and cumulative educational experiences provided to students for developing technological literacy prior to their entry into technological occupational training programs or employment. Generally, the frame of reference throughout the paper is comprised of those occupational fields considered to be "high technology" and for which training will occur at a postsecondary level. High technology is the current catch phrase that refers to new technologies that are having an impact on the business and industry sector. In defining high technology, Hull (1983) states that

> a more appropriate exercise is to identify the principal characteristics of high technology and to apply the characteristics to curriculum design for technician education. The characteristics I've identified are (1) broad knowledge base, (2) heavy involvement with computers, (3) rapidly changing technical content, (4) systems-oriented emphasis, (5) basic understandings, and (6) employee flexibility. (p. 2-3)

Technology education will be the term used to mean the general educational experiences provided at the elementary and secondary levels that contribute to development of the technological literacy necessary for the continuation of education and training in high-technology occupational fields.

Engineer, technologist, and technician are occupational roles that usually meet high-technology definitional requirements. Although some secondary vocational education program descriptions state high-technology job training objectives, it is generally accepted that universities, colleges, technical institutes, and community colleges provide the technical training for these occupations. This training, of course, occurs at several levels of theoretical and practical understanding. Thus, it is possible that multiple patterns of technology education are needed, each according to the goals of the student. The intent of this discussion is to present various views about general technology education and examples of technology programs.

As a preliminary, technology as it has an impact on life-styles, the economy, work, and education, will be examined. Following this review of the literature, educational programs will be discussed.

LIVING, LEARNING, AND EARNING IN A TECHNOLOGICAL WORLD

Toffler (1980a) has assembled and presented considerable evidence to support his contention that technological development alters all of humankind's institutions.

> Until now the human race has undergone two great waves of change, each one largely obliterating earlier cultures or civilizations and replacing them with ways of life inconceivable to those who came before. The First Wave of change—the agricultural revolution-took thousands of years to play itself out. The Second Wave—the rise of industrial civilization—took a mere three hundred years. Today, history is even more accelerative, and it is likely that the Third Wave will sweep across history and complete itself in a few decades. We who happen to share the planet at this explosive moment will therefore feel the full impact of the Third Wave in our own lives. (p. 26)

Living in a Technological World

Toffler, of course, does not speak alone. Robert Theobald (1974), Emmanuel Mesthene (1970), and Daniel Bell (1976) are a few among many who study, write, and speak of our technological future. Living in the emerging technological era will be significantly different than in the society we have known. In an address to the American Industrial Arts Association, Theobald (1974) stated:

> It just happens that we live in an extraordinary period of history: we are passing through one of the massive discontinuities between one style of life and another. Previous discontinuities took place as we moved from hunting and gathering to agriculture and from agriculture to industry.
>
> Our situation is unique, for the past discontinuities have been spread over generations, while the present process of change is taking place in a very short period of time. The process of transformation from the industrial era to the communications era will be essentially complete by the end of this century, or man will be in the process of destroying this small planet beyond hope of survival. Thus any education which repeats and replicates the patterns of the industrial era is now counter-productive. (pp. 2-3)

Just as the extended family of the agrarian era gave way to the nuclear family of the industrial period, so has this family structure deteriorated in turn. Few families in the United States today (only about 3 percent) fit the nuclear model of a working husband, housewife, and two children. In fact, one-fifth of all households are comprised of persons living alone. It appears that the family of the future will not fit a single model, but will provide for various styles according to economic, religious, personal, functional, sexual, or vocational choices (Toffler 1980a).

This change in family styles parallels changes in life-styles that already may be observed. Flexible work hours, the home as an office or work space, nontraditional work roles, shifts from strength-intensive to knowledge-intensive occupations, and problems in transportation are becoming common-place. As communications technology development continues to accelerate,

opportunities abound for restructuring patterns of family, community, and social life. Concepts of work, leisure, social obligation, family, politics, and education have undergone major changes since 1950. According to most futurists, these changes have only begun.

Although judged by many as evidence of decay in our society, increased crime, broken homes, alcohol and drug use, sexual experimentation, and unemployment are occurrances that might be expected in a transitional period. As a familiar social structure becomes less relevant, anxiety, uncertainty, and fear of the unknown result in erratic behavior.

DeVore (1983) identifies five factors involved in the evolution of a society: (1) food supply, (2) materials, (3) energy, (4) information, and (5) control of technical systems. These factors may be compared with Toffler's (1980a) conceptualization: techno-sphere, referring to energy, production, and distribution; socio-sphere, referring to interrelated social institutions; info-sphere, communications channels; and power-sphere, control. It is among these elements of society that we experience and witness change.

The industrial era from which we are emerging was energy and materials intensive. As a consequence, in the race to out-produce other companies or nations, irreplaceable energy sources were depleted, especially fossil fuels. Other natural resources were just as wantonly wasted, and the result has been and continues to be pollution of the air, water, and soil. The measure of affluence was the amount of goods produced and sold. Most Americans wished to share in that affluence, and so few questioned industrial growth. Industrialism implanted standardization, synchronization, and specialization in factories and in all aspects of our lives—homes, schools, communities, and political agencies. The advancing technological era promotes questions and challenges of and to these practices and characteristics of the industrial era.

In conjunction with its First Global Conference on the Future, the World Future Society published *Through the '80s: Thinking Globally, Acting Locally*. This volume, a collection of papers by recognized scholars, speaks to many issues facing a society in transition. Human values, health, international relations, communications, resources, and economics are among the topics presented. New values of personal satisfaction, health, and quality of life are replacing those of material wealth and economic growth (Hamrin 1980). John Platt (1980) challenges thinkers to create a self-stabilizing world society. *Through the '80s* transmits a sense of urgency that prevails regardless of the particular topic discussed.

Economics in a Technological Era

An economic basis for this urgency is reflected by John Naisbitt (1982).

> Things are not going to get better; things are going to get different. We are not in a recession, we are in something much more profound than that. We are changing economies and we haven't changed economies for a hundred and fifty years.
>
> Of course, there is a lot of uncertainty but we have got to make uncertainty our friend. We have had an economy that rested on the industrial sector, which has served us magnificently for so long, but now we are shifting to a new economy that rests on information and electronics. This is not going to happen tomorrow; it is happening today. We are more in the new economy than we are in the old economy. (p. 46)

Fundamental to industrialism is the principle of production, and the purpose of that

production is economic growth. Thus, through the years, the gross national product (GNP) has become the predominant benchmark of our economic health. It followed, then, that more goods had to be produced to increase the GNP, which, of course, directly influenced and was influenced by the numbers employed and the demand for goods. The consumer economy that flourished from the late forties through the sixties began to experience difficulties in the seventies. Excessive inflation diminished the purchasing power of the nation's workers at the same time that labor costs caused difficulties for products on the world market. Developing countries, meanwhile, were extending their technological and manufacturing capabilities. The eighties have seen these economic difficulties heighten and accelerate.

Economists with differing viewpoints work with different theoretical bases, and thus produce different, often contradictory, prognoses. Despite these differences, economic analyses, syntheses, and projections are valuable in the decision-making process. From an enormous amount of data, cycles and trends are derived. The cycles result from short-run fluctuations, while trends are synthesized from long-run cumulative patterns. Whitelaw (1983) identifies (1) inflation, (2) unemployment, (3) prime interest rates, (4) new home mortage rates, (5) distribution of income, (6) utilization of capacity, and (7) lost opportunities as major indicators in economic cycles. According to this author, except for inflation, each of these indicators will probably stay the same or worsen in the immediate future. Kahn and Phelps (1980) display moderate optimism for the longer-term economic future, especially for the rising middle-income countries, with somewhat slower growth predicted for the more affluent countries.

Toffler (1980a) speaks of a significant economic shift in the demise of "marketization" and the rise of "prosumerism." The capitalist world economy is in the midst of a downturn that started ten years ago and is predicted to last another decade (Wager 1980). Regardless of how we look at the economy, it appears to be in trouble, at least in the short run. Capitalism, as we have known it, is threatened. Massive amounts of government funds are being used to subsidize the economy. In spite of this, the past three years have seen business failures, reduced purchasing power, high unemployment, concentration of capital in fewer corporate structures, and diminished pressure for social reform measures (ibid.). All of these are evidence of what is referred to by the news media as an economic crisis.

A new technological "fix," improved productivity, and breakthroughs in cheap energy are all developments that may serve temporarily to reverse the downturn in the economy and prolong the life of the present economic system (ibid.). Reindustrialization, a term used frequently in the past few years, is an attempt at regaining our competitive edge in the world market. Leach (1982) observed two developments in a new cycle of economics in the United States: (1) a continuation of the economic policies of large industrial businesses as in the past and (2) the development of businesses in new and emerging fields. Thurow (1980) concludes that the United States and the world are headed into years of economic stagnation.

Henderson (1981) writes of the decline of the "petroleum age" and the emergence of the "solar age" wherein crises are being experienced in industrial and monetary systems. Identified are two phenomena at the dawning of the solar age: (1) the devolution of unsustainable institutions in industrial countries, with citizens attempting to recall the power previously delegated to central governments and large corporations and (2) calls at the international level for a new economic order with Third World participation.

Henderson depicts supply-side economics as a "last hurrah" attempt to prime the economic pump. This approach promotes supply and production at the expense of further damaging the society and ecosystem, exploits resources at a rapid rate, and deregulates economic activities to

the detriment of workers and society and the advantage of oil companies and other corporations. Massive military expenditures buy more inflation while social support is cut "in order to make the funny-money, GNP-measured economy appear to be growing" (p. 16). Henderson concludes that "all of this turning back the clock and attempting to restore America to some past dream of glory is little more than a doomed, rearguard action" (p. 16).

Kahn and Phelps (1980) present a slightly different view for the future. They acknowledge the problems of pollution, overcrowding, and mismanagement as "growing pains of the superindustrial economy (or society)" (p. 202).

Earning in a Technological World

Inextricably linked with economics are productivity and employment, both of which have direct relationships with education in general and vocational education in particular. Although work and the preparation and continued updating of the worker are virtually inseparable, the discussion in this section is limited to the changing nature of work in a technological world. Technological changes have an impact on all segments of economic institutions. The work force is not immune to the effects of these changes. Significiant changes have been underway since 1945. Recently, these have been structural differences brought about by rapid technological development. Joseph Coates (1982) notes that

> there is a shift in our own time from an industrial society to a service-based society driven by information. Preparation for work in the information society must be different from what has gone before, for the new information technologies are not mere analogs of the carpenter's plane and the mechanic's wrench. The new vocations will not be limited to the physical manipulation of natural and synthetic substances, but will extend to the manipulation of mans [sic] own creations. (p. 27)

Structural, economic, and social factors combine to alter the character, scope, and volume of the work force. A report by the National Commission for Employment Policy (1982) suggests that

> The 1980's are proving to be a period of tremendous change in the labor market. Among the trends that business and government leaders must consider in fashioning effective employment policies are a significant decline in labor force growth, a maturing work force, and large-scale movements of people from the Northeast and Midwest toward the West and the South and from urban to rural areas. In addition, high-technology innovations, including computers and industrial robots, and the emergence of an increasingly service-oriented economy promise to alter significantly the number and kind of employment opportunities available during the remainder of this century. (p. 1)

Shifts within the Work Force

There will be 125 million persons in the work force by 1990, according to the U.S. Bureau of Labor Statistics. The typical worker will be older and better educated than today's, and more likely to be female and living in a rural area (National Commission for Employment Policy 1982). The population of the United States will increase at a slower rate, and there will be a decreasing number of young workers entering the work force. The rate at which women enter the work force will also decrease as their numbers approach a maximum level. It is predicted that the labor force will grow in the eighties at less than half the seventies' rate.

During 1983 tremendous numbers of workers were unemployed, with a national average in excess of 10 percent. Regionally, the unemployment rate was higher, with unemployment in West Virginia, for example, at 17 percent. Among black teenage males, the unemployment rate reached approximately 50 percent. Further, structural changes in the manufacturing industries resulted in the disappearance of approximately 2 million jobs of these unemployed workers. As these industries further automate to become competitive in the world market, the number and type of jobs change. Although new jobs will be created in new sectors of the economy, such as the high-technology industries, not enough will be available to employ the dislocated workers who, by 1990, may number several additional millions (Gottlieb 1983).

Jones, Lauda, and Wright (1982) identify two forces that are altering work: (1) expanding technology and (2) a psychology of entitlement. Expanding technology needs little explanation. The psychology of entitlement relates to workers' belief in and demand for satisfaction from work. Self-fulfillment, achievement, and benefits are among the entitlements sought by workers.

DeVore (1980) traces changes in the concept of work from an agricultural society to an industrial society. Factory work demanded adjustments from outdoor to indoor work and created the need for specialization and highly differentiated occupations. Biologically derived energy (muscle power) gave way to machines and the use of heat energy. Today, work and values associated with work are changing again. Robots and computerized controls are reducing the need for humans in the production system. Work may need to be redefined to include purposeful activity without pay. This would be consistent with Henderson's (?81) nonmonetized investment and Toffler's (1980) "prosumer."

These changes are having a significant impact on emotional and intellectual lives. "Human behavior is also affected by the nature of one's specific association with technology in a given society. Those who work with computers and intricate information systems behave differently and think differently than do people whose roles are related to production or servicing sectors of society" (DeVore 1980, p. 257).

Unemployment and changing concepts of and toward work are two of many indicators of the dramatic shifts of the work force resulting from technological development. Just as there are identifiable geographic, gender, and age shifts in the work force, so there are profound changes resulting from new industries and new processes. New forms of automation are having severe worker dislocation effects, especially as traditional "smokestack" industries make changes in their production methods or shut down operations. Many workers formerly employed in these industries are without employment and the skills to compete in emerging high-technology fields (National Commission for Employment Policy 1982).

Already there have been major changes in white-collar and blue-collar occupations. In 1950, 36.6 percent of employed persons were blue-collar workers and 43.4 percent were white-collar workers. In 1980, 52.2 percent of all workers were white-collar workers. Farm workers declined from 7.9 percent to 2.8 percent of the work force in the same time period. Now white-collar workers exceed all other workers by 4.4 percent (ibid.).

Programmable Automation

In production industries, programmable automation technologies have the potential for creating major disruptions in employment. Programmable automation includes (1) robotics, (2) computer-aided design (CAD), (3) computer-aided manufacturing (CAM), (4) computer-

integrated manufacturing (CIM), (5) computer-aided process planning (CAPP), (6) automated materials handling (AMH), (7) automated storage and retrieval systems (AS/RS), and other such flexible hardware and software systems. Programmable automation combines computer and data communications with conventional machine abilities to increase process control and enables single pieces of equipment to do multiple tasks. It differs from conventional automation in that short runs and batch production, as well as large volume production, may be done economically. Worker skills are then converted from manipulation to planning, scheduling, and programming.

The Office of Technology Assessment (1983) identifies four attributes of programmable automation:

- Capacity for information processing as well as physical work, in connection with such processes as planning, routing, design, fabrication, assembly, monitoring, and diagnosing process problems

- Capacity for quality enhancement, through reliability, precision, and adaptive control of the production process

- Capacity for application to the production of a diverse mix of products, through reprogrammability

- Capacity for integrating production equipment and systems with each other and with design, analysis, inventory, and other aspects of the manufacturing process (p. 4)

These capabilities will influence the replacement of human skills by machines, the applications within which human workers and machines can be combined, programmable automation skills, and organization and management of the manufacturing process. They will also influence the types of products produced and costs of producing different quantities.

Whereas conventional automation affected employment and work largely in the blue-collar sector, programmable automation holds the potential of having significant impact on the white-collar worker as well. Specific effects of programmable automation on identified groups of people are difficult to project. However, general relationships with employment can be drawn abstractly. There are three factors that affect the development and implementation of programmable automation technologies and therefore employment and training. These are (1) the rate of technological change, (2) the nature of that change, and (3) the pattern of diffusion. The adoption rate of new technologies affects workers to a greater extent than the rate of development of that technology. In the past, adoption has lagged considerably behind development, and this lag provided some stability in the work force. Increasingly, the adoption time for new technologies has been reduced. Disagreement exists today as to whether microelectronic innovations will spread as slowly as earlier predicted.

The nature of technology also affects employment. Technology may be process or product, embodied or disembodied, and may possess capital intensity. Process technology generally is adopted to improve efficiency, which often means a reduction in the labor force. Product technology creates new sources of employment and often engages new process technologies. Embodied technologies are associated with equipment, whereas disembodied technologies constitute organizational and management methods. Disembodied technologies may often substitute for embodied ones, and the skills for each differ markedly.

Capital intensity is the investment in plant and equipment relative to other investments such as

labor. Although the history of programmable automation is too short for reliable generalizations to be made, it appears that a number of industries are purchasing robots (capital intensive) as a means of dramatically increasing productivity. Thus, a change in the work force, if not a reduction, is inevitable.

It appears that programmable automation will be diffused more broadly than was conventional automation. Small, as well as large, companies may benefit from the flexibility of these technologies. Thus, technology diffusion may affect large and small, product diverse, and geographically spread industries (Office of Technology Assessment 1983).

That programmable automation is becoming a predominant force in production industries is not disputed, but lack of agreement is evident as to the magnitude and direction of that force. Among writers, robotics is the most often cited of automation technologies—perhaps with good reason—as it presents the greatest threat to employment. For example, the 5,000 industrial robots now in use in the United States represent approximately 15,000 jobs. This figure is not too significant, as most of the dislocated workers have been retrained or would have been lost through attrition. However, it is estimated that by 1990, 100,000 to 200,000 robots will be in use in the United States. It is possible that within two to three decades a million or more robots will replace workers. At the current rate of three displacements per robot that could mean more than three million persons (Coates 1983).

Hunt and Hunt (1983) disagree with predictions of significant job dislocations resulting from technological developments such as shifts to robotics. They project a displacement of 100,000 to 200,000 jobs by 1990, rather than the millions predicted by others. They acknowledge that industrial robots, like all laborsaving devices and technological advances, reduce the need for semiskilled and unskilled workers first. Ultimately, robots' impact will in some measure affect other workers as well. Jobs created for new technologies when added to those jobs lost through implementation of technological advancements, result, finally, in reduction in jobs available.

Hunt ("Training Must Change" 1983) estimates that between 32,000 and 64,000 new jobs will be created by 1990 in robotics and related fields. Thus, part of the job loss will be shifted, but nevertheless will leave a deficit of 68,000 to 136,000 jobs. Women and nonwhites account for 3.5 million blue-collar jobs—mostly as operatives (Coates 1983). Since operative jobs will be those most rapidly displaced, these groups will suffer the greatest impact.

Overall, it seems unclear just how great an impact programmable automation technologies will have on the work force. It seems reasonably clear, however, that a net loss of employment can be expected and that those jobs created will require different and advanced training.

Information Technology

Paralleling, and not totally independent of, programmable automation as a major influence on shifts in the work force are information technologies. The direct impact of the latter is even more difficult to pinpoint than that of programmable automation. However, the transition from an industrial society to an information society is evident. The significance of this transition, as it applies to employment, is illustrated by Molitor (1981). In 1920, 53 percent of the work force was employed in manufacturing, commerce, and industry. This percentage decreased to 37 percent in 1956 and to 29 percent in 1976. Conversely, the 19 percent employed in information/knowledge/ education enterprises increased to 29 percent in 1956 and 50 percent in 1976. Molitor predicts that in the year 2000, 76 percent of the work force will be in information/knowledge/education

enterprises and other services. Manufacturing, commerce, and industry (22 percent) and agriculture and extraction (2 percent) will comprise the remainder of the labor market. It is possible that recent accelerations in computer production and usage will cause these projections to fall short of the shifts that will occur.

Advances in telecommunications and computer technologies may be more revolutionary than programmable automation. One estimate suggests that 55 percent of all workers in 1980 were engaged in generating, storing, transmitting, or manipulating data (National Commission for Employment Policy 1982). A highly technological society demands large amounts of information to aid economic, social, and political decision making. Multinational corporations, banks, airlines, and governmental agenices, in addition to educational, recreational, and social institutions, are becoming highly dependent on information technologies. Television cable systems, satellite communications, telephone networks, broadcasting stations, and informational services are among the heavy users of informational technologies. They also present a variety of employment opportunities as they create shifts in the employment scene. The literacy skills of information workers generally are expected to be better than those of workers in other fields. Information technologies are beginning to alter the skills required of secretaries and clerks and the "wired" office may eliminate the need for many workers with those job titles.

The U.S. Bureau of Labor Statistics estimates that 685,000 new jobs will be created and 250,000 replacement openings will occur in the next decade for computer professionals. These estimates are likely to be conservative because only existing, traditional job categories were examined. Design engineers, industrial engineers, and other individuals with specialized computer skills are viewed as necessary to help the average user be effective in automated systems. Whereas reliable estimates of growth in these types of jobs are unavailable, these professionals are expected to be needed in addition to the projected 2.14 million specialists to be employed by 1990 (Office of Technology Assessment 1982). This is nearly 1 million new jobs, or 7.5 percent of the total work force.

The National Science Foundation projects 157,000 baccalaureate and master's-level graduates in the computer sciences. Estimates of community college and public and private vocational school graduates have not been made (Office of Technology Assessment 1982). It appears, however, that the informational technology area is one in which the demand for employees will exceed the supply, at least for a decade. Confused signals are being transmitted about employment opportunities in this rapidly changing technological world. On one hand, technology is causing displacement of workers, and on the other, creating new jobs and occupational titles.

The infusion of new technology into the workplace provides for new and creative jobs and, potentially, a more productive society with greater equity among its participants. There is a clamor about the need for more highly educated and trained specialists, but this appears to be true only in limited fields. For example, the American Electronics Association (1983), in its report on technical work force projections in the electronics industries, states that total employment is expected to increase 49 percent in the five years from 1983-1987. That is an increase of 8.3 percent per year when compounded annually. The "hot" categories and corresponding percentages of growth include software engineers (115 percent), electronic engineering technologists (107 percent), and computer analysts/programmers (103 percent).

The belief that high technology will require more sophisticated job skills is based largely on two assumptions: first, that high technology will favor professional and technical-level jobs, and second, that high technology will upgrade skill requirements of existing jobs because of increasingly sophisticated equipment. Levin and Rumberger (1983) contradict these beliefs, stating that

despite the widespread propagation of these assumptions, both are contradicted by available evidence. Most new jobs will not be in high technology occupations, nor will the application of high technology in existing jobs require a vast upgrading of the skills of the American labor force. To the contrary, the expansion of the lowest skilled jobs in the American economy will vastly outstrip the growth of high technology ones. And the proliferation of high technology industries and their products is far more likely to reduce the skill requirements for jobs in the U.S. economy than to upgrade them. (p. 2)

The messages are unclear. New and upgraded jobs in high technology do exist and will continue to emerge. The difficulty is in knowing what form these jobs will take.

Petroskey ("Indiana's Economic Revolution" 1983) reported U.S. Bureau of Labor Statistics data showing that none of the twenty occupations with the most new openings is in high technology. In fact, the occupations expected to have the most openings are secretaries, nurses' aides, janitors, and salesclerks. Whereas six high-technology occupations are among the twenty expected to show highest percentage growth, the base is relatively small, resulting in a correspondingly small absolute number. This shows that growth is occurring in some high-technology occupations, but in relatively low numbers. Much is yet to be learned about the cycles and trends of the workplace and work force in a technological world. This unsettled condition causes problems for individuals as well as giving rise to difficulties in establishing educational and training programs to meet the needs of both individuals and employers.

Learning in a Technological World

What?

Is the systems approach a thing of the past?
Is the past a thing of the now?
Must we solve today's problems with yesterdays tools?
Are we only concerned with the how?

Is the future so tame that we need just to claim
Our solutions are there in the sky
Or do we believe, to continue to breathe,
That we need to begin asking why?

(Sapp 1972, inside front cover)

Why, What, and How

The technological age has come crashing down on all of society's institutions. Just as with the wave analogy of Toffler (1980), everything in its path is altered. A quick glance around reveals immediately that the mass education approach of the industrial era is no longer working. As societal values have changed, schools are finding that the purposes for which they stood, the curricula they promulgated, and the methods of motivation and instruction they employed are being questioned. This nation's renewed interest in education is resulting in a fresh look at these old approaches.

Whereas we may wish to attribute this renewed attention to education to a concern for education for its own sake, the recent economic crisis seems to be a greater impelling force. The dominant institution of the industrial era was the economy, and vestiges of this dominance are still apparent. Since performance of the economy was judged by the amount of consumption of goods and services, the purpose of education was directed toward turning out productive workers. This system promoted punctuality, obedience, and repetitious work, which served the industrial era well (Toffler 1980b). Thus, now as the economy encounters hard times, education is being asked to re-create economic vitality.

The long-held superiority in technology is now slipping away, accompanied by an apparent, simultaneous loss of educational superiority. The National Commission on Excellence in Education (1983) puts it as follows:

> We report to the American people that while we can take justifiable pride in what our schools and colleges have historically accomplished and contributed to the United States and the well-being of its people, the educational foundations of our society are being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people. What was unimaginable a generation ago has begun to occur—others are matching and surpassing our educational attainment. (p. 5)

Anderson (1982) agrees, noting that "if we continue down the same old education path, it will be only a matter of time until we forfeit the technological leadership upon which this country's economic growth depends" (p. i). He is referring, of course, to the international race for supremacy in high-technology development. Just as Sputnik in 1957 alerted the United States to its relaxed mathematics and science educational progress, so has the recent economic crisis awakened us. At least five commission reports issued in 1983, mostly within a two-month period, addressed the issue of educational excellence. This concern for excellence in education is directly related to a corresponding concern for economic recovery, employment, and national security.

It has been said that education has two purposes. One is to teach people how to make a living and the other how to live. Often these two goals appear to be in conflict. But as technology has changed life-styles, attitudes, occupations, values, and the workplace, it must certainly be recognized that education cannot be solely oriented toward either vocational skills or liberal arts. The basics of a bygone era do not meet today's needs, much less those of tomorrow. The Education Commission of the States' (1983) Task Force on Education for Economic Growth suggests new skills for a new age:

> Technological change and global competition make it imperative to equip students in public schools with skills that go beyond the "basics." For productive participation in a society that depends ever more heavily on technology, students will need more than minimum competence in reading, writing, mathematics, science, reasoning, the use of computers, and other areas. (p. 9)

The Carnegie Foundation for the Advancement of Teaching suggests that the time has come—

- to clarify the goals of education,
- to stress the centrality of language and link the curriculum to a changing national and global context,
- to recognize that all students must be prepared for a lifetime of both work and further education, and

- to take full advantage of the information revolution and link technology more effectively to teaching and learning in the schools. (Boyer 1983, p. 7)

Deficiencies In The System

The National Science Board Commission on Precollege Education in Mathematics, Science and Technology (1983) released a report on education in September 1983. In its findings and recommendations, much was said about the quality of elementary and secondary education. This resembles somewhat the reports of the National Commission on Excellence in Education (1983), the Education Commission of the States' (1983) Task Force on Education for Economic Growth, and the Carnegie Foundation for the Advancement of Teaching (Boyer 1983). In a "Fact Sheet" released with its report, the National Science Board Commission States:

> The participation and achievement of America's 17-year-olds in mathematics and science have been dropping steadily since the late 1960s. . . . Between the 1973 and 1982 National Assessments of Mathematics, mean achievement scores of 17-year-olds declined 3.2 percent. Between 1970 and 1983, the National Assessments of Science mean achievement scores of 17-year-olds declined 6.7 percent. Only 74.5 percent of our young people now graduate from high school. Other countries have made dramatic gains. For example, 94 percent of Japanese youths now complete high school. (p. 1)

Educational deficits occur in all aspects of schooling, or so it would seem from the reports. The Education Commission of the States Task Force on Education for Economic Growth (1983) reports, for example, that 1979 testing demonstrated that 13 percent of seventeen-year-olds could not perform minimal, functional literacy reading tasks, 53 percent could not correct a billing error through writing a letter, and only 15 percent could write a persuasive statement. In addition, 40-50 percent of all urban students have serious reading problems, and the proportion of students enrolled in mathematics and science courses declined from 60 percent to 48 percent between 1960 and 1977.

When compared with other countries, the United States also received a poor report card. In the United States, only 38 percent of high school students take a one-year course in cnemistry, whereas in the Soviet Union 100 percent of the students complete four years of chemistry. Quantitative comparisons are made not only in what students take, but also in the time students are exposed to learning. In the United States, school is in session an average of 180 days, as compared with 240 days in most other industrialized nations. The length of the school day is also greater in those countries. Students completing twelve years of school in other industrialized countries have an equivalent of four years more school comprised of a much more demanding curriculum than graduates of high schools in the United States.

An argument in favor of our shorter school year might be that our educational system is more effective. However, the evidence is not encouraging. On nineteen international student academic achievement test comparisons, American students never placed first or second, and they placed last on seven of these tests. The average achievement on standardized tests in the U.S. is lower than twenty-six years ago when Sputnik was launched (National Commission on Excellence in Education 1983).

Teacher preparation and preparedness fair no better, perhaps worse, than that of students. Current shortages of qualified mathematics and science teachers are widely publicized. Inadequacies of fully qualified and certified teachers are not as well known, but also exist. The

Education Commission of the States' (1983) Task Force on Education for Economic Growth reports that 26 percent of all mathematics teaching positions are filled with noncertified or temporarily certified teachers, and 51 percent of elementary teachers report no undergraduate training in science.

The Carnegie report (Boyer 1983) indicates that about 11 percent of all American high school students earn six or more credits in vocational education. Seventy-eight percent of U.S. high school students take at least one vocational course in an area of special interest or as a graduation requirement. "But when it comes to preparing students for a specific job and putting them on the first rung of the career ladder," says Boyer (1983), the results of vocational education are largely disappointing" (p. 120). The Carnegie report goes on to state that

> a recent comprehensive survey confirmed our informal observations. The study concluded that job prospects for graduates of vocational programs are not much better, overall, than they are for students in the nonspecialized curriculum. There is, the survey reports, essentially no difference in employment advantages between male graduates of high school trade, industry, and business programs, on the one hand, and male general education graduates on the other.
>
> The one exception is "secretarial science." Studies reveal that female graduates of commercial-business programs (who do not go on for more education) have higher levels of employment than do young women who graduate from the general studies program. But even this advantage seems to decrease as time passes. (Ibid., p. 121)

These educational shortcomings draw attention to the interrelatedness of all of education with the political, social, and economic activities of society. The technological lead of the United States is being threatened by the educational and technological advancements of other countries. It appears that this technological edge will be further diminished as the educational edge gained by those countries begins to be reflected more dramatically in technological developments abroad. The National Science Board Commission (1983) states that "the Nation that dramatically led the world into the age of technology is failing to provide its own children with the intellectual tools needed for the 21st century" (p. v).

If the American technological edge is to be retained, if competition in the world marketplace is to be a national priority, if national security depends upon technological development, then neither education nor industry can afford to continue on a business-as-usual basis. According to Frey (1983),

> knowledge is going to be this country's most precious resource. American industry will have to be wiser and more innovative, relying on ever more advanced technology to compete effectively. American workers will have to be smarter, more sophisticated, go to school longer, and be better trained. (p. 27)

It seems abundantly clear that education in and for the future must be improved. The National Science Board Commission (1983) summarizes the problem succinctly:

> We must return to basics, but the "basics" of the 21st century are not only reading, writing and arithmetic. They include communication and higher problem-solving skills, and scientific and technological literacy—the thinking tools that allow us to understand the technological world around us.

By 1995, the Nation must provide, for all its youth, a level of mathematics, science and technology education that is the finest in the world, without sacrificing the American birthright of personal choice, equity and opportunity. (p. v)

PREPARATION FOR WORK IN A TECHNOLOGICAL WORLD

As has been pointed out throughout the foregoing sections, technology has an impact on every aspect of society. This is especially noticeable in the workplace. Occupations are made obsolete at an increasing rate, structural unemployment occurs, new jobs are created, training and retraining are constants. With change occurring so rapidly, the preparation of individuals for work in the technological world becomes an increasingly difficult task.

Although technology has this pervasive influence, it has been predicted that only 7 percent of the new jobs in the United States will be in the glamour occupations of high technology. More than three times as many janitors will be needed as computer systems analysts, and opportunities for fast-food workers and kitchen helpers exceed five times the opportunities for computer programmers (Boyer 1983; Levin and Rumberger 1983). Thus, it is a myth that everyone needs to be trained for work in high technology. Only three or four of the occupations projected as the top twenty contributing to job growth by 1990 require education beyond the secondary level.

The Education Commission of the States' (1983) Task Force on Education for Economic Growth classifies today's jobs under four titles: (1) unskilled jobs—can be performed by persons with less than today's basic skills, (2) basic jobs—require the educational basics, (3) learning-to-learn jobs—demand the basic skills and the capability of learning new ones (analysis and problem solving), and (4) professional jobs—require the learning-to-learn skills plus adaptability and more sophisticated intellectual skills as well. The demands of higher-level technological jobs place most of them in the learning-to-learn and professional categories. However, it should be understood that no one in this society is immune to technology's influence and the need for developing technological literacy.

Two questions immediately arise: How do individuals prepare for work in high-technology occupations? And its corollary: What kind of preparation is needed for those occupations? Answers to these questions are essential before the issue of education for technological literacy can be resolved.

It is generally accepted that training for high-technology occupations occurs at the postsecondary level ("Training Must Change" 1983; McCormick 1983; Pedrotti 1983). If the occupation is engineering, the training occurs at the university level, as does some preparation for industrial and engineering technologists. Technician-level preparation is usually completed in two-year institutions, such as community colleges or postsecondary technical schools. Some secondary-level training programs for high-technology equipment maintenance do exist. However, industry executives (in Ohio for example) express a preference for employees with postsecondary training (McCormick 1983). More skills training is provided by employers than by schools. In fact, recent studies show that 68 percent of job-related courses are furnished in-house. Cost analyses show that more than 55 percent of expenditures for job-related education and training are being incurred by nonschool providers ("Employers, Not Schools, Furnish Most Job Training" 1983).

High-technology occupations are so new and varied that planning programs for them is of major concern to postsecondary institutions. In an attempt to respond to this need, the National

Center for Research in Vocational Education produced a number of guides to aid postsecondary curriculum planners in developing high-technology programs. These publications provide information about the skills required in the high-technology occupations included. For example, a basic curriculum outline for a CAD/CAM program includes these subjects:

- Computer science with programming languages such as COBOL and FORTRAN
- CAD/CAM functions and technical instructions
- CAM economics and finance
- Process technology (materials and processes)
- Physical sciences (including physics, chemistry, and electronics)
- Mathematics through calculus and analytical geometry (Abram et al. 1983)

Robotics technician competencies parallel those of the CAD/CAM technician with less emphasis on materials and processes and greater depth in computer languages and hardware. Thus, a synthesis suggests that the math and sciences, computer sciences, and economics (as specified for CAD/CAM) would be equally appropriate for robotics. Additionally, though not mentioned, reading, writing, and oral communication skills would be essential to succeed in such programs.

From all observations, jobs in high-technology occupations require sophisticated technical knowledge, analytical skills, communication skills, general mathematics, and scientific knowledge. Additionally, understanding of basic technologies and fundamental statistics is mentioned as important by industrial executives (McCormick 1983).

The impact of advancing technologies on job content is less clear. Not only the variety, but also the levels of skills needed are uncertain. While it is known that some jobs require higher-skill levels than others, these may be altered by process-control decisions. Equally unclear is the effect advanced automation will have on job satisfaction. In other words, it remains to be seen whether high-technology jobs will provide more variety, stimulation, and challenge than those in traditional industries. Roles and responsibilities at all levels may be changed, altering the distribution of power as well as the nature of jobs. Obviously, all of these factors result in implications for the preparation of individuals for work.

The Office of Technology Assessment (1983) cites three factors impeding the development of coordinated and flexible occupational instruction:

> First, the absence of long-range, public and private projections of skill requirements, particularly those that highlight changes in skill levels and in core skill requirements within occupations, has hindered the development and delivery of instructional programs before industrial demand reaches critical proportions. Second, a history of responding to changing industrial skills requirements as crises arise has perpetuated a fragmented approach to education and training. Little or no planning or coordination of efforts takes place among traditional educators, business, labor, government, and others. Third, rapid technological change has placed great strain on educators as they attempt to adapt instruction to the requirements of new technology, while at the same time they address other changes in instructional needs. (pp. 31-32)

Levin and Rumberger (1983) disagree with widely held views that high technology will raise occupational skill levels on a broad scale, and, consequently, mathematics, science, and technical applications training levels. Instead, they suggest that, different skills may be required of workers due to technological and industrial shifts, but not higher-level skills. Except for relatively small numbers of specialized jobs, the majority of workers will not need higher-level skills.

The conclusions of Hunt and Hunt (1983) about the impact of robotics support the views of Levin and Rumberger (1983) regarding the numbers of highly trained individuals needed. They state that, "we have identified two very different problems, a potential oversupply of robotics technicians and a probable shortage of engineers" (p. 177). On a somewhat contradictory note, they refer frequently to the "skill-twist" that results in a continuing decline in manual skills and an increase in the need for technical and scientific knowledge and skill. Their report strongly emphasizes breadth in training to permit flexibility in employment.

In addition to uncertainty about skill levels required for the work place of the future, there arise questions about who is to receive instruction, who is to provide it, and by what method it will be delivered. Of course, these are not all the questions that might be asked, only those that will be briefly addressed.

First, the number of those participating in instructional programs for the workplace is as difficult to pinpoint as skill levels. It is known that approximately 11 percent of secondary students are enrolled in vocational preparatory programs (Boyer 1983). Twenty-one million people, or 13 percent of the adult population, participated in adult education programs in 1981, of which, approximately 60 percent participated for job-related reasons. Industry in the United States spends $40 billion annually on education and training of its employees, and this amount excludes instructor fees, administrative costs, equipment, and travel (Office of Technology Assessment 1983). Conceivably, most youth and adults are potential participants in instructional programs for the workplace.

Second, the institutions, agencies, and organizations that may provide education and training are as varied as the individuals to be served. The Office of Technology Assessment (1982) in *Informational Technology and Its Impact on American Education* presents descriptions of the characteristics and contributions of the following systems:

- Elementary and secondary education, public and private
- University and four-year colleges
- Two-year and community colleges
- Proprietary education
- Education in the home
- Libraries
- Museums
- Business and labor

As comprehensive as this listing is, the military services are not included, and it is well known that

technical training by military schools ranks highly. Business and labor, two-year and community colleges, and universities and four-year colleges are looked upon as the primary providers of high-technology education and training.

Third, the methods of delivery of education and training vary widely. Traditional secondary and postsecondary vocational and technical programs have relied largely on laboratory/shop activities with some cooperative work arrangements. The use of technology in their instruction has been limited. Business and labor have utilized technology in instruction to a greater extent, but often purchase instruction from outside agencies. Of the 40 percent of manufacturing plants utilizing programmable automation in 1982, according to an Office of Technology Assessment survey, 22 percent sponsored or conducted new technology education or training. Producers of such high technology, however, provide instruction for their customers (Office of Technology Assessment 1983). Both users and producers rely heavily on in-house instructional methods. Colleges and universities have used the most traditional methods of instruction, but some change is beginning to be apparent, especially in the community colleges. Instructional television and computer-aided instruction are beginning to make some impact, but, informational technology generally is in a very early stage of development and use.

Summary

In the preparation of individuals for work in a technological world, it may be seen that (1) youth need to be prepared for entering a work force that is extremely varied and in a state of constant change, (2) preparation for employment in high-technology occupations is not appropriate for all individuals, as higher levels of mathematics, science, and communication skills are necessary; (3) dislocated workers need new skills to be able to reenter the work force in different roles; (4) presently employed workers need continually to renew skills to maintain employment or to upgrade their roles; (5) new concepts of work and the work place are evolving rapidly, and (6) basic skills, as recently redefined, are essential elements for entry into any high-technology education and training program.

TECHNOLOGICAL LITERACY AND TECHNOLOGY EDUCATION

> Schools, like bridges and roads, are part of the economic infrastructure of the U.S. Although the decay of roads and bridges provides a visible manifestation of societal neglect, schools have suffered a more insidious decline. They are crumbling under the growing weight of our multiple expectations, conflicting demands, and poor planning. This decline is particularly alarming, because our economic and social systems are increasingly dependent on a high level of technology that can be effectively managed only by the technologically literate graduates of a first- rate school system. (Hersh 1983, p. 635)

The previous sections provide an overview of societal conditions, future projections, economic influences, work force changes and difficulties, educational processes and problems, and work force preparation characteristics. This background was provided as a means of describing the parameters of technology education. The literature indicates the following:

- Technology and technological development affect every aspect of our society—on a local, state, national, and international level.
- Technological development and educational development are closely related.
- Economic development and technological development are closely related.
- The United States competes economically with other technologically developing countries.
- The United States' educational supremacy is being lost to other countries.
- The United States' technological supremacy is eroding.
- High technology has created a dichotomy in the work force.
- Employment in high-technology occupations requires a higher level of education and training than industrial occupations of the past.
- Preparation for high-technology occupations can be provided by many different agencies or institutions, most of which offer postsecondary-level training.
- The role of elementary and secondary educational institutions is to prepare individuals for satisfactory living in a technological world, including for many a readiness to benefit from preparatory programs in high-technology occupations.

These observations are presented as assumptions underlying education that precedes specific occupational education or training—or pretechnology education. The term *pretechnology education*, is imprecise, as it implies much more than the general technological literacy needed for

entry into a vocational training program. Pretechnology education, then, is intended to mean the body of knowledge and the skills an individual must possess to benefit effectively from further, more specific technological education and training at the postsecondary level. It may well be that this is the same education needed by all individuals for satisfactory and effective living in a technological world—regardless of occupational choice.

The Basics for a Technological Society

In the recent past, much attention has been given to the need for a return to the "basics" in education. On the surface, this appears to reflect a consensus. However, much disagreement exists on what constitutes these basics. This fact, coupled with the economic crisis of the late 1970s and early 1980s, probably can be credited with the renewed attention being focused upon education. Task forces, commissions, individual research commissioned by organizations, joint industry-education study groups, and foundations have recently come forward with observations and recommendations for providing educational remedies to problems at the elementary and secondary levels.

Based upon their analysis of occupational trends in a technological world, Levin and Rumberger (1983) contend that most future jobs will not require a high level of mathematics, science, and computer skills. They propose three guidelines for planning future educational programs:

> First, the general educational requirements for creating good citizens and productive workers are not likely to be altered significantly by high technology. Everyone should acquire strong analytic, expressive, communicative, and computational skills as well as extensive knowledge of political, economic, social, and cultural institutions. . . .
>
> Second, since we cannot predict in any precise sense which jobs will be available to particular persons, which jobs they will select from among those available, and what the characteristics of jobs will be over a forty-year working life, it is best to provide students with a strong general education and ability to adapt to a changing work environment. Such adaptation requires a sufficient store of information about culture, language, society and technology, as well as the ability to apply that information and acquire new knowledge. Accordingly, general academic and vocational preparation should be stressed, as opposed to specific training, especially for young students. . . .
>
> Third, if changes in work requirements arise abruptly and change occurs at a faster rate than previously, the educational system may need to respond more quickly and efficiently to training needs. It may require better ties with industry and should not exclude the possibility of more industry-based training activities. (p. 12)

These views do not differ significantly from those of Jones, Lauda, and Wright (1982), who propose to defer vocational choice until after grade twelve so that an adequate background for career decision making and vocational maturity may be accumulated. "Considering the complexity of our technological society, we could begin to take advantage of the extended adolescent period by emphasizing more career/technology awareness at the primary and secondary level. A new structure should be developed for the technical professionals of the future by reorganizing the vocational education program and providing its services as a funded postsecondary educational opportunity" (p. 17).

Hersh (1983) suggests that literacy is more than the back-to-basics advocates promote—"that the competence to sort, analyze, and synthesize a virtual bombardment of information" is essential (p. 637). He states that "in the post-industrial age, the difference between the haves and the have-nots will be measured in terms of technological literacy" (ibid.). Hersh further describes this technological literacy as extending beyond knowledge of mathematics, science, and computer technology:

> One must also know how to use this knowledge. Within this frame of reference, *technological literacy* means possession of the necessary abilities to engage in complex thinking, i.e., the possession of an appropriate fund of knowledge and the skills to tap a continuously changing information base.
>
> More than ever, critical thinking is necessary for effective functioning—and critical thinking does not derive solely from high-quality instruction in science and math. Deficiencies in students' performances in these areas are only symptoms of the more fundamental problem of poor school practices. (Ibid.)

Dennis Sapp, engineer and professor of construction technology, expressed views similar to those of Hersh in correspondence with the author (September 1972) as to what should constitute pretechnology education.

> Certainly, it seems it should go without saying that a thorough grounding in the three R's—especially emphasizing at least an introductory level competence in mathematics through basic differential and integral calculus, and including at least descriptive and perhaps projective geometry— is absolutely mandatory in pretechnology education. In the context of today's fiercely competitive, global technological marketplace, it seems ridiculous that any engineering, science, or technology programs should be required to offer remedial courses in these fundamental areas. Such programs must go far beyond these basics.
>
> The basic "pre-technology" need I wish to emphasize here—one I believe to be at least as, if not more, important than those mentioned above—one, however, that is perhaps less well defined and specified in engineering, science, and technology program requirements—and one not limited to the field of technology, but important to all fields—is that of training in, and knowledge of, the functioning of the human observing-thinking-behaving process.

This refers to critical thinking, the development of curiosity and interest in the physical world, and the limitations of the human mind. Quoting Richard P. Feynman, Nobel Laureate in physics, Sapp asserts that "one ought not be afraid not to know, for not knowing (and knowing it) is the mother of technical creativity."

Consensus has developed that mathematics, sciences, and communication skills, with the addition of computer literacy, technological literacy, and critical thinking abilities are requisities of technology education. In a recent conference on high technology (Advisory Council for Technical-Vocational Education in Texas 1982), for example, the presenters repeatedly addressed the theme of technological impact and the need for more sophistication in the educational process and the integration of the computer into all high-technology pursuits.

The Basics: Specific Recommendations

At no time in recent history has so much attention been focused upon American education. As previously mentioned, several nationally constituted commissions, task forces, and foundations have come forth in just one year with recommendations designed to achieve excellence in education. Some of these reports are summarized in the following sections.

National Commission on Excellence in Education (NCEE)

The NCEE report, *A Nation at Risk*, was released in April 1983 and stimulated debate across the country. Three of the report's five major recommendations are relevant to the purposes of this paper. These three reflect what NCEE views as basic education in a technological society:

- First, high school graduation requirements should be more demanding and encompass the "new basics"—(1) four years of English, (2) three years of mathematics, (3) three years of science, (4) three years of social studies, (5) one-half year of computer science, and (6) for college-bound students two years of foreign language

- Second, more rigorous and measurable standards and high expectations for student conduct and academic performance are called for

- Third, more time should be devoted to learning the "new basics"—possibly a longer school day, longer school year, or more effective use of that time now allocated to school

Education Commission of the States' Task Force on Education For Economic Growth (ECS)

The ECS report, *Action for Excellence*, was released in June 1983 in response to technological change and global competition and the resulting need of the educational system to go beyond the basics. The report makes eight recommendations to emphasize that more than minimum competence in reading, writing, mathematics, science, reasoning, the use of computers, and other selected areas is necessary. The challenge is to raise both the floor and ceiling of educational achievement in the United States. The recommendations for future action are as follows:

- Develop—and put into effect as promptly as possible—plans for improving education in the public schools from kindergarten through grade 12. (p. 34)

- Create broader and more effective partnerships for improving education in the states and communities of the nation. (p. 35)

- Marshall the resources that are essential for improving the public schools. (p. 36)

- Express a new and higher regard for teachers and for the profession of teaching. (p. 37)

- Make the academic experience more intense and more productive. (p. 38)

- Provide quality assurance in education. (p. 39)

- Improve leadership and management in the schools. (p. 40)

- Better serve those students who are now unserved or underserved. (p. 40)

The College Board

The Educational "EQuality" Project of the College Board (1983) stresses equality in and quality of education. The report presents recommendations from a multi year study conducted by The College Board. Subject areas and competences needed by all college entrants—two-year and four-year—are defined. Academic competencies in reading, writing, speaking and listening, mathematics, reasoning, and studying are described. Computer competency is identified as an emerging need, and the involved competencies are outlined. Additionally, "observing" is suggested as a competency to be considered in efforts to define curricula. Learning outcomes are detailed in the basic academic subjects of English, the arts, mathematics, science, social studies, and foreign language. Although technology education was not specifically mentioned as a subject area or a competency, the learning outcomes contained frequent reference to technology related knowledge.

National Science Board Commission on Precollege Education in Mathematics, Science, and Technology (NSB)

In September 1983 the NSB released a report of the commission's seventeen-month study of education. The NSB plan went beyond other reports in giving specific recommendations for making the United States' elementary and secondary mathematics, science, and technology education the world's finest by 1995. The commission's report makes recommendations for leadership, direction, time allocation, teacher and teaching improvement, and upgrading what is taught and learned. In addition to recommendations for raising the requirements for mathematics, science, and technology, both quantitatively and qualitatively, new educational objectives are presented. These are addressed by topic for each level.

Technology is accorded great importance in the National Science Board (1983) study.

> Technology, which grows out of scientific discovery, has changed and will continue to change our society. Students must be prepared to understand technological innovation, the productivity of technology, the impacts of the products of technology on the quality of life, and the need for critical evaluation of societal matters involving the consequences of technology. (p. 44)

The report further stresses the use of information technologies in instruction and learning. Educational uses of the computer are given extensive coverage.

The NSB report recommends that, in addition to extending and improving mathematics, science, and technology education at the elementary and middle school levels, high school graduation requirements should be revised. It is recommended that students complete at least three years of high school mathematics (including one year of algebra, and at least three years of science and technology, including one semester of computer science). For college admission, the recommended requirements are four years of high school science (including physics, chemistry, and one semester of computer science), and four years of mathematics (including a second year of algebra and course work covering probability and statistics). Appropriate counseling is

recommended so that students may know well in advance about the courses required to meet college entrance requirements.

Carnegie Foundation for the Advancement of Teaching

Also in the fall of 1983, the Carnegie Foundation released the report of its study of American secondary education that began in the spring of 1980. While recognizing that examples exist of high standards and achievement in the high schools, the foundation recommends a comprehensive school-improvement program, stating that "without excellence in education, the promise of America cannot be fulfilled" (Boyer 1983, p. 301). Twelve priorities for an action agenda were identified in this publication:

- **Clarifying Goals:** Every high school should establish clearly stated goals that focus on mastery of the language, a core of common learning, preparation for work and further education, and community and civic service.
- **The Centrality of Language:** All students need to be proficient in the primary language of the culture that leads to clear thinking, communication, and understanding.
- **The Curriculum Has a Core:*** Required courses should be expanded to two-thirds of the total units required and in addition to strengthening mathematics, science, history, and literature, emphasis should be given to foreign language, the arts, civics, nonwestern studies, technology, the meaning of work, and the importance of health.
- **Transition: To Work and Learning:** A single track should be developed for all students with the first two years devoted heavily to the core curriculum and the final two considered "a transitional school" in which approximately one-half time is devoted to elective clusters to include advanced academic studies, career option exploration, or combinations of the two.
- **Service: The New Carnegie Unit:** A service requirement of one Carnegie unit should be included for each student to perform volunteer work in the community or school.
- **Teachers: Renewing the Profession:** A comprehensive proposal is made for changes in the teaching field, including responsibilities, rewards, activities, salaries, preparation and continuing education, evaluation, and advancement.
- **Instruction: a Time for Learning:** Teaching styles, standards of expectation, and materials are recommended for change.
- **Technology: Extending the Teacher's Reach:** The use of computers and other technology is urged, with cautions about goals, objectives, and appropriateness of the equipment.

*Specific recommendations for each of the areas in the core curriculum were provided. The two that follow are especially relevant to this discussion: (1) "All students should study technology: the history of man's use of tools, how science and technology have been joined, and the ethical and social issues technology has raised" and (2) "The one-semester study of work we propose would ask how attitudes toward work have changed through the years. How do they differ from one culture to another? What determines the status and rewards of different forms of work? Such a curriculum might also include an in-depth investigation of one specific occupation" (Boyer 1983, p. 304).

- **Flexibility: Patterns to Fit Purpose:** Flexibility in scheduling, location of schools, and arrangements should be used to serve gifted and talented as well as disadvantaged youth.

- **The Principal as Leader:** Authority, freedom, and responsibility are recommended for the school principal to provide leadership in rebuilding excellence.

- **Strengthening Connections:** School-college and school-business/industry connections should be maintained to aid students and strengthen programs.

- **Excellence: The Public Commitment:** Citizens and local, state, and national governments must work together to bring excellence to the schools.

The core of common learning proposed by the report includes the following specifics:

- Language—5 units
- History—2.5 units
- Civics—1 unit
- Science—2 units
- Mathematics—2 units
- Technology—.5 units
- Health—.5 units
- Seminar on work—.5 units
- Senior independent project—.5 units (pp. 303-305)

These would total 114.5 units or two-thirds of the required units. Within categories, substantive changes were recommended, that is, under language, two units of foreign language and one-half unit of arts were included. The technology, seminar on work, and independent project recommendations were unique and aimed at bridging the gap between school and life outside the school.

These reports, as well as the other literature, clearly support the need for increased levels of mathematical, scientific, verbal, and technological skills for all students in the advancing technological world. Further, critical thinking and reasoning abilities are given as essentials. Computer literacy is viewed as necessary to support all learning and working activities. These skills contribute to the technological literacy and technology education essential not only to effective living, but also to the economic well-being of this country.

Pretechnology Programs

The development of pretechnology programs is so recent that few program descriptions appear in the literature. Hull and Pedrotti (1983), in writing of the knowledge and skills needed by high-technology technicians, state:

A well-designed curriculum that prepares technicians to succeed in high-tech occupations is both comprehensive and demanding. Students entering such programs need sufficient competence in scientific, mathematical and verbal skills and must also have some computer literacy. The requisite skills ought to include a demonstrated proficiency in one year of high school algebra and a reasonable proficiency in writing and speaking. (p. 31)

A secondary program designed to prepare students for postsecondary or university programs in high technology—technicians in the first case and engineers in the latter—must have as a foundation the same basic skills as those recommended for technological literacy. These skills in communication, science, and math (along with computer skills) are not sufficient in themselves, however.

Mikulecky and Diehl (1983) put it this way: "Reading a textbook to memorize facts is far different from reading reports, manuals, tables, diagrams and printouts in order to get the job done. Increasingly, it has become part of the vocational educator's task to help close this gap" (p. 34). This task is not an easy one. The all-important requirement, "and the one most difficult to program in the school environment, is the ability to apply these basic disciplines to tools, materials, processes, controls, and energy conversion systems" (Pedrotti 1983, p. 23).

The focus in many secondary school vocational programs has been on preparing students for employment. This approach will continue to be appropriate for some occupations. Training for most technicians in high-technology fields, however, must be designed to prepare students for postsecondary programs on in-house training provided by employers. (The movement into high-technology occupations is illustrated in figure 1.)

In a workshop sponsored by the American Vocational Association and the Center for Occupational Research and Development (1983), reference was made to the need for articulation between secondary and postsecondary vocational programs. Called a "two plus two," an articulated program model was presented. This program involves two years of secondary school pretech courses and two years of postsecondary technological courses.

Richmond County Board of Education

Richmond County Board of Education in Augusta, Georgia, offers a pretech curriculum that prepares students for entry into either two-year high-technology programs or four-year degree programs in engineering. Requirements of this "pre-tech" program appear in table 1.

The American Industrial Arts Association (AIAA) adopted a three-year Professional Improvement Plan (Starkweather 1983) for meeting the technology education needs of elementary and secondary youth. This plan is built around the assumption that technology education is essential in the education of citizens of a technological society. Starkweather (1983) states:

Therefore, the mission of professionals in the industrial arts/technology education field must be to increase understanding of technology among all people. To achieve this mission, industrial arts education will provide a comprehensive, contemporary technology education for all. This program, by its very nature, will provide insight for learners into the evolution, appropriate use, and significance of technology; the organization, systems, personnel, techniques, resources, and products of industry; and the social and cultural impacts of both industry and technology. (p. 8)

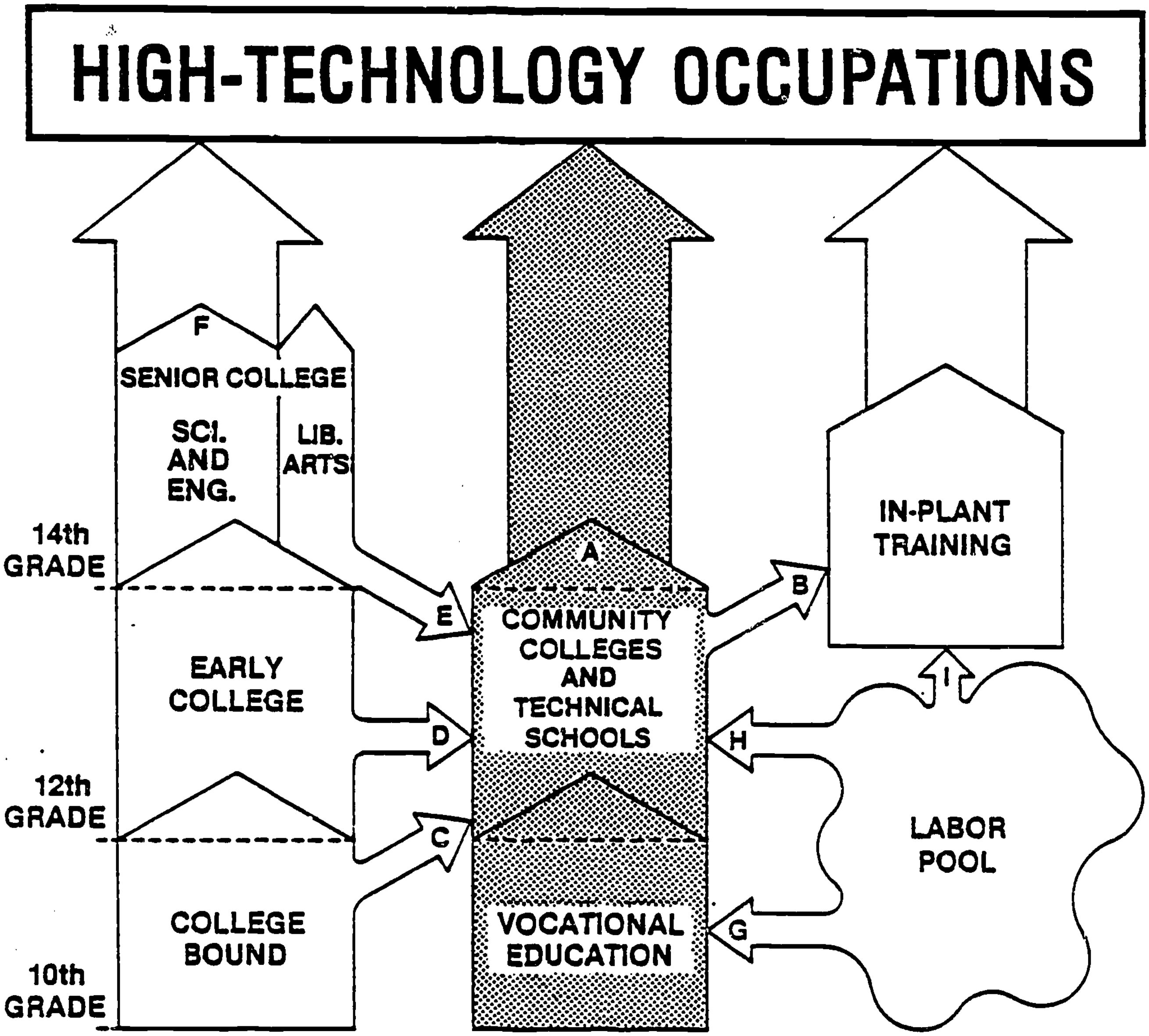


Figure 1: High-Technology Occupations

SOURCE: Center for Occupational Research and Development, 1983; p. 26.

TABLE 1

PRETECH PROGRAM

Units	Subject Area or Course
4	Language Arts
4	Math (Algebra I and II, Geometry, Trigonometry, Advanced Algebra)
4	Science (Physical Science, General Biology A, Health, Chemistry, Physics)
2 1/2	Social Studies (Citizenship, 1 semester World History or World Geography, American History)
1/2	Previewing the World of Work
1/2	Private Enterprise
1/2	Physical Education
1/2	Technical Communications
5	Pretech Electives (Pretech courses may be selected from the following, but must include at least one-half unit in drafting, one-half unit in computers, and two in either electronics or electromechanics.) Drafting; Industrial Arts; Metalworking; Electronics or Electromechanics; Computer Courses (available in both Business and Math Departments)
2	Electives

SOURCE: Center for Occupational Research and Development 1983, p. 135.

Goals of the improvement plan are that all AIAA members will:

- pursue the ideal form of industrial arts/technology education to ensure technological literacy of all people.
- profit from personnel development experiences nurturing programs that apply technology to societal problems.
- exchange ideas and practices within and outside the profession to foster a positive, consistent view of industrial arts/technology education. (p. 9)

Objectives and strategies of the plan were developed to reach all states and all personnel so as to establish pilot programs in forty states by 1986. The goal defined was to transform industrial arts from its traditional form to a dynamic technology education program that meets the needs of the future.

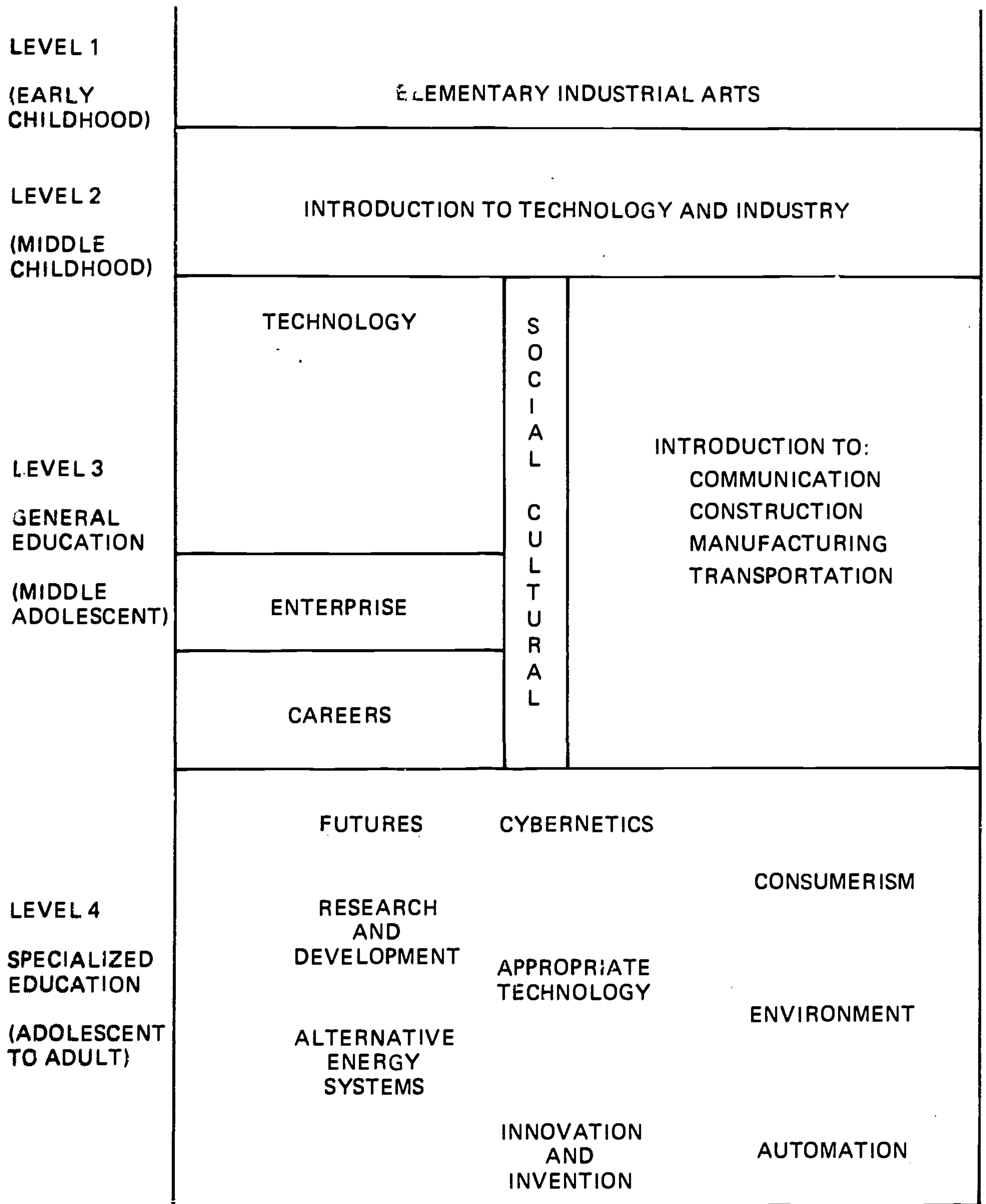
Technological literacy has been a primary focus of many in the field of industrial arts for more than a decade (DeVore 1980; Lauda 1976; Lemons 1972). Although many attempts have been made to make technology education the content for industrial arts (Maley 1973; Olson 1963), few programs have made the transition. Recently, a new effort has resulted in the development of a conceptual base for industrial arts. Known as the Jackson's Mill Project, this effort has been the merging of different thrusts into a common philosophy that emphasizes technology as a study. This study would focus on the adaptive systems of humankind with a particular concentration on their technological aspects. A scope and sequence model is shown in figure 2. The significance of this effort is that it has brought together differing factions from several decades into agreement on a common direction (Hales and Snyder 1981).

Programs for the New Technologies

As discussed previously, programmable automation is becoming an important force for change in industry. Such technologies as robotics, CAD, CAM, CIM, CAPP, AHM, and AS/AR are eliminating traditional jobs and creating new ones. The exact nature—magnitude and direction—of these changes is unclear. This uncertainty, coupled with the common elements of programmable automation technologies, is leading vocational educators to design programs in general areas such as engineering technology with majors offered in specific technologies such as CAD and robotics.

A high-technology curriculum was developed for this type of program by the Center for Occupational Research and Development (1983). Building upon a basic foundation of communications, computer literacy, mathematics, science, and socioeconomics, the program moves to a technical core of courses and finishes with a specialization. Figure 3 illustrates this sequence.

Known as United Technical Concepts (UTC), the curriculum designed to achieve this end is an alternative program for presenting in a uniformed way what traditionally had been taught as isolated courses. Programmable technologies often are comprised of micro-electronic, thermodynamic, pneumatic, optical, and mechanical subsystems. UTC treats thirteen concepts across four major systems—mechanical (transitional and rotational), fluidal, electrical, and thermal. These concepts include:



SOURCE: Adapted from Hales and Snyder 1981.

Figure 2: Scope and Sequence of Technology Education

- Force
- Work
- Rate
- Momentum
- Resistance
- Power
- Potential and kinetic energy
- Force transformers
- Energy converters
- Transducers
- Vibrations and waves
- Time constants
- Radiation

Information about implementing programs at both secondary and postsecondary levels is available from CORD.

Lorain County Community College

Implemented in 1983, the engineering technologies program at Lorain County Community College in Elyria, Ohio is based on the UTC curriculum (Peebles, n.d.). Five major areas are offered:

- Computer-aided design (CAD)
- Computer systems technology
- Computer numerical control technology (CNC)
- Microelectronics technology
- Robotics technology

Program requirements appear in table 2. Prerequisites include high school algebra and geometry and either proficiency or credits in mathematics at the postsecondary level.

Included in *UTC Physics at Lorain County Community College* (Peebles, n.d.) is information about implementing programs including planning, financial, facilities, staffing, equipment, and

High Technology Curriculum Structure

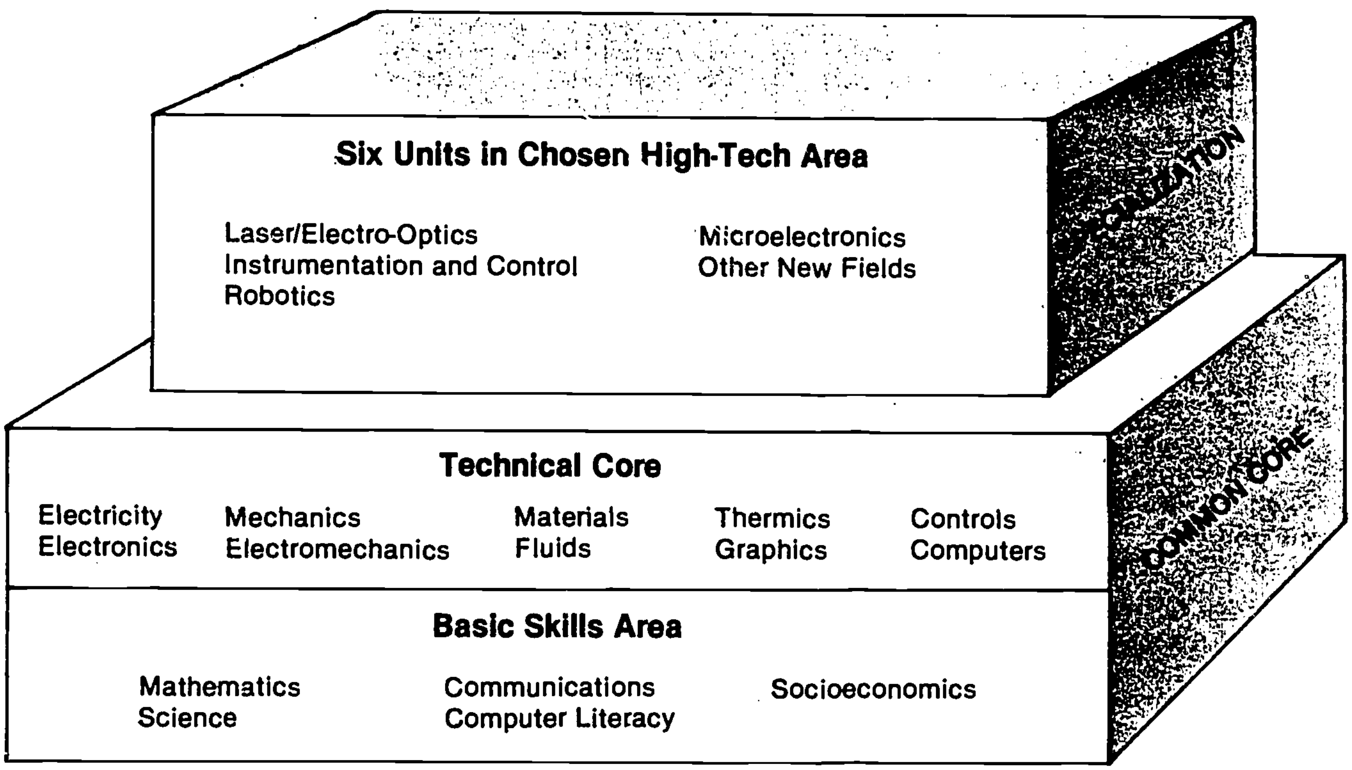


Figure 3: High Technology Curriculum Structure

SOURCE: Hull and Pedrotti, 1983.

scheduling. The college held a workshop in 1983 for individuals interested in implementing similar programs.

Robotics Technology Program

Developed at the National Center for Research in Vocational Education by a project sponsored by the Office of Vocational and Adult Education, U.S. Department of Education, *Preparing for High Technology: Robotics Programs* (Ashley, Abram, Konopka, and Carrico 1983) lists technician-level competencies and a sample course outline (see table 3). Course descriptions are also presented along with guidelines for program planning and information about equipment requirements and staff technical capabilities.

Summary

Education has come under severe criticism in the past decade, and vocational education has received its share of that criticism. Regardless of occupational or career paths chosen, living in a high-technology age requires better education than previous eras and, consequently, better education than the educational system provided during recent decades.

Several commissions have examined the U.S. educational system and current and future societal needs and assessed the relative position of the United States compared to that of other technologically developed countries. They found the United States lacking. Many writers agree that specialized education and training must occur at the secondary level. The amount of knowledge accumulated by society and the sophistication of technology make this necessary. Until now little guidance was available for planning "technology education." Results of major studies now point the way toward increased requirements in mathematics, science, writing and communication, languages, computer and technological literacy, and thinking and reasoning skills.

Postsecondary education has come to be recognized as the level at which high-technology training will occur—whether in two-year or four-year programs. A few excellent examples exist of pretechnology and technology education programs, and information is available about implementing such programs.

TABLE 2

ENGINEERING TECHNOLOGIES PROGRAM

Common Core		54 Credit Hours
MATH 111	Technical Mathematics II	5
MATH 112	Technical Mathematics III	5
MATH 113	Technical Calculus	5
ENG 101	Communication Skills I	3
ENG 102	Communication Skills II	3
ENG 103	Communication Skills III	3
PHYS 121	Unified Technical Physics I	5
PHYS 122	Unified Technical Physics II	5
PHYS 123	Unified Technical Physics III	5
PSYC 211	Basic Career Concepts	3
ECON 211	Basic Concepts of Economics	3
SOCI 211	Basic Career Concepts	3
BSAD 270	Industrial Relations	3
CPSC 140	Computer Science	3
High Technology Technical Core Courses		43 Credit Hours
HTTC 110	Graphics I	2
HTTC 112	Graphics II	3
HTTC 150	Manufacturing Processes	5
HTTC 130	Mechanical Devices	3
HTTC 120	Circuit Analysis	4
HTTC 122	Electronic Devices and Systems	5
HTTC 124	Electrical Power and Devices	5
HTTC 160	Properties of Materials	3
HTTC 128	Microprocessors	5
HTTC 140	Fluid Power	3
HTTC 126	Instrumentation and Controls	5
Major Courses		29 Credit Hours

1. Robotics
2. Microelectronics
3. Computer Aided Design
4. Automated Machining/Computer Numerical Control
5. Computer Systems

SOURCE: Adapted from Peebles, n.d.

TABLE 3

ROBOTICS PROGRAM

- **Fluid Power**

  FP 100 Applied Hydraulics and Pneumatics
  FP 101 Hydraulic and Pneumatic Circuit Analysis

- **Electro-Mechanical**

  EM 110 Basic Electromechanics
  EM 111 Servo Valves and Sensors
  EM 210 Electrical Controls and Automation Circuits
  EM 211 Electromechanical Servicing

- **Electrical/Electronic**

  EE 120 DC and AC Circuit Analysis
  EE 121 Transistor Circuit Theory
  EE 122 Drive Circuits
  EE 220 Digital Logic and Computer Circuits
  EE 221 Computer-Aided Circuit Analysis
  EE 230 Microprocessors - Software
  EE 240 Microprocessors - Hardware
  EE 250 Industrial Control Systems

- **Robotics and Automated Manufacturing**

  RA 130 Introduction to Robots
  RA 131 Machine Tool Processes
  RA 230 Robotic Interfacing
  RA 240 Robotic Applications (Basic)
  RA 241 Robotic Applications (Advanced)
  RA 250 Automated Systems Servicing
  RA 260 Problem Solving/Internship

- **Quality Control Technology**

  QC 150 Metrology (Optional)

SOURCE: Adapted from Ashley et al. 1983.

Of the many conclusions which might be drawn from the foregoing review, three summarize the major themes. These are:

- **The economic well-being of the United States, and consequently, stability in the society is heavily dependent upon maintaining a competitive level of high technology.** Even though the economic system of the past one hundred fifty years is in the throes of substantial change, continued development of technology is essential to the social and political institutions of the society. During the transition to a global economy, cycles of prosperity and poverty will place unusual demands on all countries, especially those that have been affluent in the past.

- **The workplace and the work force of the future will be significantly different from those of the past and the present.** "Smokestack" manufacturing has given way to service industry, and future work sites may increasingly move to the home or small establishments. Manufacturing has been replaced by service industries as the predominant employer. Information systems will provide for major employment in the immediate future. As technological development continues to accelerate, Third World countries will perform much of the work normally done by manufacturing firms of the industrial era. Increasingly, workers will have to maintain flexibility and accept a lifetime-education-and-training concept. The dichotomy between high-technology and low-technology workers will deepen.

- **Technology education develops technological literacy, and technological literacy is the basis for work or preparation for work in a technological society.** Pretechnology education (or technological literacy) is comprised of an optimum degree of mathematics and science competencies, a high level of reading and writing skills, an ability to use the computer effectively, thinking and reasoning abilities in a technical context, and a knowledge of technology and the ethical and social impacts of its development and application. Technological literacy is fundamental to all citizens and especially necessary for those engaged in or preparing for careers of a technological nature.

REFERENCES

Abram, Robert; Ashley, William L.; Hofman, Robert; and Thompson, Jack W. *Preparing for High Technology: CAD/CAM Programs*. Columbus: The National Center for Research in Vocational Education, The Ohio State University, 1983.

Advisory Council for Technical-Vocational Education in Texas. *Statewide Conference on High Technology: Proceedings*. Austin, TX: Texas Education Agency, October 1982.

American Electronics Association. *Technical Employment Projections of Professionals and Paraprofessionals, 1983-1987*. Palo Alto, CA: American Electronics Association, 1983.

Anderson, William S. "The Technology Race: How America Could Lose." An address given at University of Tampa, September 17, 1982. Dayton, OH: NCR Corporation, 1982.

Ashley, William; Abram, Robert; Konopka, Edward; and Carrico, Lloyd R. *Preparing for High Technology: Robotics Programs*. Columbus: The National Center for Research in Vocational Education, The Ohio State University, 1983.

Bell, Daniel. *The Coming of Post-Industrial Society: A Venture in Social Forecasting*. New York: Basic Books, 1978.

Boyer, Ernest L. *High School: A Report on Secondary Education in America*. Carnegie Foundation for the Advancement of Teaching. New York: Harper and Row, 1983.

Center for Occupational Research and Development. "Innovative Delivery Systems." In *High Technology Vocational Programs: Resource Guide*, pp. 133- 148. Waco, TX: CORD, 1983.

Coates, Joseph F. "The Changing Nature of Work," *VocEd* 57, no. 1 (January-February 1982): 27.

Coates, Vary T. "The Potential Impact of Robotics." *The Futurist* 17, no. 1 (February 1983): 28-32.

The College Board. *Academic Preparation for College: What Students Need to Know and Be Able to Do*. New York: The College Board, 1983.

DeVore, Paul W. *Technology: An Introduction*. Worcester, MA: Davis Publications, 1980.

DeVore, Paul W. "Technology, Society and Education," *Thresholds in Education* 9, no. 2 (May 1983): 2-8.

Education Commission of the States. *Action for Excellence*. Denver, CO: Education Commission of the States, Task Force on Education for Economic Growth, 1983.

"Employers, Not Schools, Furnish Most Job Training." *Manpower and Vocational Education Weekly* 23 June 1983, p.1.

Frey, Donald N. "The Economy, Productivity, and Training," *USA Today*, May 1983, pp. 25-27.

Groff, Warren H. "The Economics and Social Impacts of the Transition From the Industrial Society to A Computer Literate, High Technology, Information Society." An address presented at a colloquium, April, 1983.

Gottlieb, Daniel. "High Technology Training Surges." *High Technology* 3, no. 10 (October 1983): 70-73.

Hales, James A., and Snyder, James F. *Jackson's Mill Industrial Arts Curriculum Theory*. Reston, VA: American Industrial Arts Association, 1981.

Hamrin, Robert. "Managing Growth Through Epochal Change." In *Through the '80s: Thinking Globally, Acting Locally*, edited by Frank Feather. Washington, DC: World Future Society, 1980.

Henderson, Hazel. "Thinking Globally—Acting Locally: Ethics for the Solar Age." *National Forum* 61, no. 3 (Summer 1981): 13-17.

Hersh, Richard H. "How to Avoid Becoming a Nation of Technopeasants." *Phi Delta Kappan* 64, no. 9 (May 1983): 635-638.

Hull, Daniel M. "What Is High Technology?" In *Developing High Technology Vocational Programs*. Waco, TX: Center for Occupational Research and Development, 1983.

Hull, Daniel M., and Pedrotti, Leno S. "Meeting the High-Tech Challenge." *VocEd*, 58, no. 4 (May 1983): 28-31.

Hunt, H. Allan, and Hunt, Timothy L. *Human Resource Implications of Robotics*. Kalamazoo, MI: W. E. Upjohn Institute for Employment Research, 1983.

"Indiana's Economic Revolution: Indiana's 1990 Jobs Picture Too Fuzzy to See." *The Indianapolis Star*, 29 August 1983, pp. 1, 6.

Jones, Ronald; Lauda, Donald; and Wright, John. *Work and Education in the Eighties: Monograph 9*. American Council on Industrial Arts Teacher Education. Reston, VA: American Industrial Arts Association, 1982.

Kahn, Herman, and Phelps, John G. "The Economic Future." In *Through the '80s: Thinking Globally, Acting Locally*, edited by Frank Feather. Washington, DC: World Future Society, 1980.

Lauda, Donald P. "Technology as Content: Can Teacher Education Cope?" In *Crossroads '76, Addresses and Proceedings of the 38th and 5th International Conference of the American Industrial Arts Association*. pp. 102- 109. Reston, VA: American Industrial Arts Association, 1976.

Leach, James A. *Reindustrialization Implication for Vocational Education*. Columbus: The National Center for Research in Vocational Education, The Ohio State University, 1982.

Lemons, C. Dale. "Technology/Society Relationships: The Primary Emphasis of Industrial Arts." Paper presented at the 59th Mississippi Valley Industrial Arts Conference, St. Louis, MO, 10 November 1972.

Levin, Henry M., and Rumberger, Russell W. *The Implications of High Technology*. Project Report No. 83A4. Washington, DC: National Institute of Education, 1983.

McCormick, Robert W. "Vocational-Technical Education Interface with Ohio's High Technology Business and Industrial Sector." Final Report. Columbus: Ohio Advisory Council for Vocational Education, 1983. Mimeo.

Maley, Donald. "The Application of Technology in the Solution of Major Problems that Face Mankind in the Future." In *Industrial Arts in Senior High Schools*, edited by R. E. Lockett. American Council on Industrial Arts Teacher Education, 22nd Yearbook. Bloomington, IL: McKnight, 1973.

Mesthene, Emanuel G. *Technological Change*. New York: The New American Library, 1970.

Mikulecky, Larry, and Diehl, William. "Reading for Vocational Literacy." *VocEd* 58, no. 5 (August 1983): 34-5.

Molitor, Graham T. T. "The Information Society: The Path to Post-Industrial Growth." *The Futurist* 15, no. 2 (April 1981): 24.

Naisbitt, John. *Megatrends: Ten New Directions Transforming Our Lives*. New York: Warner Books, 1982.

National Commission for Employment Policy. "8th Annual Report: The Work Revolution," Report No. 15. Washington, DC: National Commission for Employment Policy, 1982.

National Commission on Excellence in Education. *A Nation At Risk*. Washington, DC: Government Printing Office, 1983.

National Science Board Commission on Precollege Education in Mathmatics, Science and Technology. *Educating Americans for the 21st Century: A Plan of Action for Improving Mathematics, Science and Technology Education for All American Elementary and Secondary Students So That Their Achievement Is the Best in the World by 1995*. Washington, DC: National Science Foundation, 1983.

Office of Technology Assessment. *Automation and the Workplace*. Washington, DC: Government Printing Office, 1983.

Office of Technology Assessment. *Informational Technology and Its Impact on American Education*. Washington, DC: Government Printing Office, 1982.

Olson, Delmar W. *Industrial Arts and Technology*. Englewood Cliffs, NJ: Prentice-Hall, 1963.

Peebles, Herbert E. *UTC Physics at Lorain County Community College*. Elyria, OH: Lorain County Community College, n.d.

Pedrotti, Leno S. "Redesigning Vo-Tech Curricula." In *High Technology Vocational Programs*, pp. 21-82. Waco, TX: Center for Occupational Research and Development, 1983.

Platt. John. "The Greatest Evolutionary Jump in History," In *Through the '80s: Thinking Globally, Acting Locally*, edited by Frank Feather, pp. 12-15. Washington, DC: World Future Society, 1980.

Sapp, Dennis H. "What?" *ETC. A Review of General Semantics*. September, 1972.

Starkweather, Kendall N. "AIAA: Pioneering Leadership in Industrial Arts/Technology Education." *Man Society Technology* 42, no. 8 (May/June 1983): 8-12.

Theobald, Robert. "Education or Training: Alternative Futures for Teachers." In *Industrial Arts and a Humane Technology for the Future*, pp. 2-3. Reston, VA: American Industrial Arts Association, 1974.

Thurow, Lester. *The Zerosum Society*. New York: Basic Books, 1980.

Toffler, Alvin. *The Third Wave*. New York: William Marrow, 1980.

Toffler, Alvin. "Third Wave." In *Through the '80s: Thinking Globally, Acting Locally*, edited by Frank Feather, p. 10. Washington, DC: World Future Society, 1980a.

Toffler, Alvin. *Future Shock*. New York: Random House, 1970.

"Training Must Change as Use of Robots Grows, Experts Agree." *Manpower and Vocational Education Weekly*, 26 May 1983, pp. 3-4.

"U.S. Firms Must Adapt Faster." *The Columbus Dispatch*, 10 July 1983.

Wager, Warren W. "Technocracy As the Highest Stage of Capitalism." In *Through the '80s: Thinking Globally, Acting Locally*, edited by Frank Feather. Washington, DC: World Future Society, 1980.

Whitelaw, W. "The Economy and The College Student." In *Current Issues in Higher Education (1982-83)*, pp. 4-11. Washington, DC: American Association for Higher Education, 1983.