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ABSTRACT

This report addresses productivity and technology from the perspective of state vocational education agencies. Chapter 1 explores the meaning and measurement of productivity and the benefits of productivity improvement--profits, a weapon against inflation, success in international trade, increased standard of living, improved quality of life, and equality of economic opportunity. In chapter 2, four major technological innovations and their consequent skills implications are briefly discussed. The four technologies are microprocessors, robotics, computer-assisted design, computer-assisted manufacturing systems, and the office of the future. Chapter 3 examines major external forces influencing America's present productivity position, including the thirst for capital, the shrinking share in foreign trade, a segmented economy, the job creation process, labor shortages, and the management climate. Chapter 4 suggests specific strategies and mechanisms for use by state-level vocational education agency personnel in productivity improvement efforts. Suggestions are grouped according to major agency functions: program planning, program funding, research and development, professional development, technical assistance, administration, and business/industry linkages. (YLB)

VOCATIONAL EDUCATION: ITS ROLE IN PRODUCTIVITY IMPROVEMENT AND TECHNOLOGICAL INNOVATION

by

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FOREWORD

Productivity is a critical economic concern. Sagging productivity growth coupled with rising costs and heightened foreign competition are placing American business and industry in an increasingly vulnerable position. In an effort to strengthen its competitive position, American business and industry is investing heavily in capital-intensive technology. However, productivity is people-dependent and its improvement conditioned upon their possessing the technical and organizational skills necessary to utilize technology to its fullest advantage. The development of the work skills required to contribute to the revitalization of America is the central challenge to vocational education.

This report is the result of a contract with the U.S. Department of Education, Office of Vocational and Adult Education to investigate the changing role of vocational education in productivity improvement. The report describes the relation between productivity and technology; explores the meaning and measurement of productivity; examines the nature of the productivity problem; discusses briefly four major technological innovations and their consequent skills implications; examines major external forces influencing our present productivity position; and presents mechanisms for state vocational agency use in productivity improvement and technological innovation.

Seven companion reports: "Technologies of the '80s: Their Impact on Vocational Agriculture Occupations; . . . Distribution Occupations; . . . Health Occupations," etc. describe major new and emerging technological innovations that can be expected to influence worker skills. An associated project report, "Working for America: A Worker-Centered Approach to Productivity Improvement," is devoted to an examination of worker-centered productivity and a discussion of the organizational and educational strategies for its improvement.

Individuals who are especially interested in the specific strategies and mechanisims suggested for use by state level vocational education agency personnel in productivity improvement efforts may choose to read Chapter IV of this report ("Intervention Strategies") first.

The following represent some of the observations and mechanisms included in the paper:

- Vocational education cannot be static--it must restructure its own organization to meet the needs of a restructuring economy.
- A back-to-the-basics movement is needed and is developing with regard to technical areas such as mathematics, physics, computer programming, etc. but with the emphasis on applying these knowledges under the settings and conditions found in the work-a-day world.
- Vocational education must have the flexibility to react rapidly and responsibly to specific short-term training needs.
- Vocational education can provide small businesses those functions normally performed by a training department.
- A state vocational education agency can begin productivity/technology awareness-building efforts in the agency itself as well as in local programs and institutions across the state.
- A specific state agency individual should have designated responsibility for productivity/technology concerns.

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CHAPTER I

A PRODUCTIVITY PERSPECTIVE

PRODUCTIVITY--ITS MEANING AND MEASUREMENT

Twenty years ago, productivity was a dusty concept ignored by the public and scorned by labor as a ploy to extract more work for the same amount of pay. Today, productivity is on center stage. Productivity statistics are regularly reported in the nation's newspapers and the analysis of productivity trends and comparisons with other countries the subject of frequent articles in popular magazines and professional publications. Productivity centers have been established and are researching the causes that contribute to productivity growth. At the national level, the U.S. Congress has held a number of hearings devoted to the productivity issue. President Reagan has appointed a productivity commission to study the issues. Public interest has ignited with nearly 80 percent of the general public expressing the belief that productivity is one of the most serious problems facing the country during the decade of the 80's (Harris, 1981).

Vocational educators have due cause to wonder what is this thing called productivity and what are its implications. Productivity is a deceptively simple concept that interacts in complex ways. In the essence, productivity can be regarded as the efficiency with which work is performed. Efficiency, according to the engineers, is determined by the ratio of system output to system input. The more output that is produced per unit of input, the more efficient the system is said to be.

Whereas efficiency is a concept applicable to all systems, productivity derives its meaning in the context of a production system. A production system is defined as any work organization that uses physical and/or human resources to produce material goods and/or services. As shown in Figure 1, resources are the input to the system and goods and/or services the output of the production system.

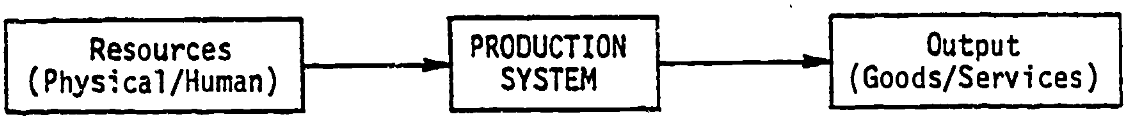

Figure 1: An Input/Output Model

Given this definition of a production system, and the equivalence of productivity and efficiency, productivity is defined as:

$$\text{Productivity} = \frac{\text{Output (system products)}}{\text{Input (resources used)}}$$

Productivity, therefore, increases when more outputs are produced per unit of input and conversely, decreases when fewer outputs are produced per unit of input.

Defining productivity as an output/input ratio has several important implications. The first is that productivity is a measure of system efficiencies, not system effectiveness. System effectiveness is a measure of the extent to which system outputs satisfy an external demand. Productivity is basically a supply-side concept, whereas effectiveness is more a measure of the demand-supply match. To confound productivity with effectiveness is to dilute the meaning of each separate concept with resulting ambiguity and confusion of meaning.

By defining productivity as a measure of the efficiency of the production system, productivity becomes a characteristic of the production system. The implication is that productivity is an organizational rather than an individual measure. Whereas performance appraisal provides management with information on which to base personnel decisions, productivity provides information at the organizational level regarding the efficiency with which organizational resources are being utilized. Since there is definite need for information at both individual and organizational levels, and since performance appraisal is an already established technique for individual appraisal, there is strong justification for the use of productivity as an organizational measure.

The physical and human resources used by a production system can be further classified as labor, capital, materials, and energy. These four resource types are termed by the economists <u>factors of production</u> and play a major role in contemporary economic theory. In order to determine the comparative efficiency with which the system utilizes its resources, productivity can be defined for each individual factor of production considered separately and for all the factors of production considered simultaneously. Thus,

$$\text{Labor Productivity} = \frac{\text{System Output (products or services produced)}}{\text{Labor Used}}$$

$$\text{Capital Productivity} = \frac{\text{System Output (products or services produced)}}{\text{Capital Used}}$$

$$\text{Materials Productivity} = \frac{\text{Output (products or services produced)}}{\text{Materials Used}}$$

$$\text{Energy Productivity} = \frac{\text{System Output (products or services produced)}}{\text{Energy Used}}$$

$$\text{Total Factor Productivity} = \frac{\text{System Output (products or services produced)}}{\text{Total Amount of Resources Used}}$$

In this manner, it is possible to determine the productivity attributed to each factor of production as well as the productivity resulting when all factors of production are used simultaneously. It is worth noting that individual factor productivity need not equal total factor productivity. Nor need all the individual factor productivity indicators be necessarily equal.

System output is generally measured using one of three major measurement units. Output may be simply measured by counting the number of physical units produced or by computing some aggregate total such as pounds or tons produced, square feet or board feet packaged, total number of liters pumped, or other such physical measures descriptive of the total amount of goods or services produced. Output may also be measured by determining the dollar value of products sold or services rendered. A variant is to measure output in terms of value added by the productive process. Value added is defined as the dollar value of goods and/or services produced less the cost of materials and contracted services performed outside of the system. The resulting value is an estimate of the increase in value of output attributed to the producing system.

System input may also be measured in either physical quantity or in dollar value. Measurement in terms of physical units is generally preferred in that physical units represent a more direct measure of resources used. However, there are situations in which differences in physical units preclude aggregation. A typical example is that of capital productivity. Because of the differences in equipment and machinery utilized, the most meaningful measure is to convert machines and equipment to a common dollar base and to measure capital utilized according to dollar value. A similar situation is likely to occur for materials. The cost of materials consumed is used as a proxy measure for the physical quantity.

Outputs will generally have to be converted to a dollar value in order to compute total factor productivity. Because of differences in physical units, the measurement of total resources used will have to be converted to dollars and the total factor productivity computed using dollar units.

Measurement of productivity is susceptible to bias from several major sources. Use of dollar value to measure either output and/or input is a function of price as well as quantity. Because price is subject to inflationary pressure, an increase in dollar value may be due totally or in large part to a price increase rather than an increase in real output or in resources consumed. If effective price changes are not controlled, productivity measures taken at different times are not directly comparable since they would reflect price variablility as well as changes in productive efficiency. The effects of price changes can be controlled by maintaining a price series for the output and/or the factor of production and deflating the dollar value of current output or input to a selected base year price. The deflated value of the output and/or input would then represent the best estimate of the real value independent of price changes.

Total number of hours paid for is frequently used as a measure of resource utilization when computing labor productivity at the national level. This measure is subject to several well-known sources of potential bias. One source is the increased number of working hours that are not devoted to producing goods and services. This results in part from increased vacation time and other perquisites that serve to increase the nonproductive time spent on the job. Use of hours paid for as an indicator of labor contribution assumes that an hour worked is equally productive regardless of the skills level. Thus, an hour worked by an unskilled laborer is treated for productivity purposes as equivalent to an hour's worth of work from a skilled craftsperson or professional employee.

Sources of bias exist in a measurement of product output as well. Measurement of output in terms of the dollar value of products sold may be influenced by market conditions rather than the contribution of resources used. Similarly, a rise in labor productivity, rather than reflecting an increase in the contribution of labor, may instead result from increased capital being provided to the worker. Conversely, a decline in labor productivity may not necessarily signal a diminution in the quality of labor. Such a condition might arise from falling outputs and an inability of employers to reduce the size of the labor force at a corresponding rate.

An associated problem in the measurement of output is the difficulty in assessing the contribution of indirect labor, i.e., labor not directly involved in the immediate production of goods and/or services. Problems in the definition of output have impeded efforts at establishing productivity indices for management and supervisory workers as well as for federal, state and local government employees.

Most of the currently available productivity statistics are collected at the macro level. The Bureau of Labor Statistics measures labor productivity in terms of dollar value of total output per hour of employment paid for. This measurement, while useful as an indicator of the productivity of the national economy considered as a productive system is subject to the major sources of measurement bias previously discussed. Although indicative of the productivity condition of the national economy, this measure of labor productivity is frequently too global to direct management efforts at productivity improvement at the establishment and firm level.

THE BENEFITS OF PRODUCTIVITY IMPROVEMENT

The benefits accruing from productivity can best be understood from the perspective of the firm level. Production costs result from the firm's having to pay the price for the factors of production used. Revenues result from selling goods and services. Profits are traditionally defined as the difference between revenue and cost. Given this definition, common sense indicates that profits will increase if product revenue increases at a more rapid rate than product costs. Carl Thor (1981) of the American Productivity Center has incorporated this notion in the concept of total profitability which is defined as follows:

$$\text{Total Profitability} = \frac{\text{Total Revenue}}{\text{Product Cost}} = \frac{\text{Product Quantity Sold} \times \text{Unit Price}}{\text{Resource Quantity Used} \times \text{Unit Cost}}$$

Alternatively, total profitability can be rewritten as:

$$\text{Total Profitability} = \frac{\text{Total Revenue}}{\text{Product Cost}} = \frac{\text{Product Quantity Sold}}{\text{Resource Quantity Used}} \times \frac{\text{Unit Price}}{\text{Unit Cost}}$$

$$= \text{Productivity} \times \text{Price Recovery}$$

The implication of this relationship is that the total profit picture of a firm is the function of 1) productivity and, 2) the ratio of product price to resource price. This ratio is termed <u>price recovery</u>

and represents the amount of product price recovered per unit cost of resources used. Price over-recovery is said to occur when a product price increases at a more rapid rate than the resource price. Conversely, product under-recovery is said to occur when the resource price increases at a faster rate than product price. Assuming that productivity remains constant, short-term profitability will increase in the case of price over-recovery and decrease in the case of price under-recovery.

As an example of the interaction of productivity and price recovery in determining total profitability, consider the following situation. A firm sells 40 units of a product at a unit price of \$3. Twenty units of resources were consumed in producing the products at a unit resource cost of \$5. The total profitability is, therefore,

$$\text{Total profitability} = \frac{40 \times \$3}{20 \times \$5} = 1.2$$

Suppose now the firm management undertakes to achieve profit growth by adopting a price under-recovery strategy coupled with an active effort to improve resource productivity. The firm lowers its per unit product price to \$2.90 and sells 45 units. Twenty-one units of resources are required to produce the product and, in conjunction with its price under-recovery strategy, per unit resource costs are increased to \$5.18. Accordingly,

$$\text{Total profitability} = \frac{45 \times \$2.90}{21 \times \$5.18} = 1.2$$

Total profitability remains the same in both cases. That is, the firm continues to receive \$1.20 in revenues for every \$1 of cost expended. However, profit as the difference between product revenues and product costs has increased from \$20 to \$21.72--a gain of nearly 9 percent.

An interesting point is that profit increased at the same time that resource costs were increasing. Resource costs increased from \$5 to \$5.18, which reflected a gain of nearly 4 percent. Since resource costs arise from a charge for the use of resources, this increase in resource costs represents an increased return to the factors of production.

The reason why both profit and return to the factors of production show an increase rests in the interaction between productivity and price recovery. Price recovery declined from \$3/\$5 = .6 to \$2.90/\$5.18 =.56. All other things equal, a decline in price recovery would have resulted in a decline in the profit position. However, this decline was offset by rising productivity. Total factor productivity increased from 40/20 = 2.0 to 45/21 = 2.14. This rise in productivity was sufficient to offset the reduction in price recovery and provided the margin that supported both an increase in profits <u>and</u> an increased rate of return to labor and capital.

Had the firm undertaken a strategy of price over-recovery, a different set of outcomes could be hypothesized. Increased product prices may well have resulted in fewer units of products being sold, thus decreasing revenues. Unused capacity and/or difficulties in adjusting the size of the labor force would likely cause decreases in total factor productivity. If productivity fell at a more rapid rate than the price recovery ratio was increasing, the overall result would be a decline in total profitability. The implication is that, in many situations, a reduction of price recovery resulting from a decrease in product pricas and/or an increase in resource costs are conducive to productivity gains with resulting benefits in the form of increased profits and returns to labor and capital.

Whereas the example is at the firm level, the principles generalize to the national scene. In a capitalistic society, economic growth is dependent upon the ability to show a profit. As the example indicated, productivity is the key to profitability. Without the ability to produce more products through the improved utilization of resources, total profitability cannot be maintained. Since total profitability is the determiner of economic growth, productiva use of scarce resources is of critical urgency. In order to maintain the margin of profitability and to provide for increasing returns to the factors of production, increased demand must be satisfied through the use of proportionately less resources. This is the heart of the productivity challenge.

Productivity is the chief free market weapon in the fight against inflation. In the absence of productivity growth, firms are forced to adopt a price over-recovery strategy. Although beneficial to profit in the short run, this strategy has long-term deleterious effects in that it exerts inflationary pressure on the economy. Dependency upon changes in price recovery rather than changes in productivity to achieve changes in the profit picture place upward pressures on the price structure. As product prices are increased, there is corresponding pressure to increase resource prices, thus triggering a wage-price spiral. Enhanced productivity on the other hand, is noninflationary in that it represents an increase in real output that can be used to offset corresponding decreases in the price recovery ratio. As shown by the example, total profitability can be maintained and the return to labor and capital increase while at the same time product prices are held constant or reduced provided that productivity shows a compensating gain.

International trade is coming to constitute an important sector of demand. If our economy is to compete for this important market, it must be priced competitively with other foreign suppliers. This means that American firms must increasingly turn to pricing under-recovery as the source of profit growth. Success in international markets will depend in large part upon our ability to supply quality products at a competitive price structure. The capability to maintain profitability and competitive pricing will depend upon the extent to which productivity can be depended upon to give us the competitive edge.

The standard of living for society flows from the stock of goods and services that the economy is able to produce. The more goods and services (cars, stereos, clothing, medical care), the higher the standard of living. The capacity of a society to provide an increasing array of goods and services for its members is a direct function of the efficiency of its resource utilization. To the extent that more can be produced with proportionately less resources, the standard of living will increase. Productivity improvement, as illustrated in the example, supplies the critical edge that allows for increased returns to productive resources in terms of wages, rent and interest.

Quality of life reflects a subjective judgement of the ability of society to satisfy personal needs. The capability of a society to provide a satisfying environment for its inhabitants is a function of both the effectiveness and the efficiency with which resources are used. Since productivity deals only with efficiency, its contribution to quality of life is bounded accordingly. However, effectiveness and efficiency are interrelated to the extent that resources must be efficently used in order to be truly effective. Since quality of life is an evaluation of the effectiveness of society in achieving its goals, productivity makes its contribution to the achievement of selected goals through improved efficiency of resource utilization towards achievement of selected ends.

Equality of economic opportunity has become an avowed national purpose. Productivity contributes to this end by promoting economic growth and an enhanced standard of living. Economic growth requires increased resources needed to supply an expanding pool of goods and services. The increased demand for resources translates into increased economic opportunity for disadvantaged segments of the society. As the stock of real outputs produced by the society increases, so does the amount available to all segments.

THE PRODUCTIVITY PROBLEM

Labor productivity as measured by output per employee hour is on a downhill slide. The extent of this decline can be determined by examining the annual rates of productivity growth. Annual percent changes for the private business sector for the years 1948-1981 are given below:

1948 - 3.8%	1965 - 3.8%
1949 - 1.6%	1966 - 3.2%
1950 - 7.9%	1967 - 2.0%
1951 - 2.8%	1968 - 3.3%
1952 - 2.8%	1969 - 0.2%

1953 - 3.1%	1970 - 0.7%
1954 - 1.6%	1971 - 3.6%
1955 - 4.0%	1972 - 3.5%
1956 - 1.3%	1973 - 2.7%
1957 - 2.8%	1974 - -2.3%
1958 - 2.5%	1975 - 2.3%
1959 - 3.2%	1976 - 3.3%
1960 - 1.6%	1977 - 2.1%
1961 - 3.1%	1978 - -0.2%
1962 - 4.5%	1979 - -0.3%
1963 - 3.8%	1980 - -0.2%
1964 - 4.0%	1981 - 1.0%

Source: Bureau of Labor Statistics data as presented in a Statement of the Chamber of Commerce of the United States on Productivity presented to the Subcommittee on the Senate Committee on Labor and Human Relations, April 2, 1982.

This series covers four rather distinct time periods. The decade 1948 to 1958 reflects the emergence from World War II. The period 1959 to 1968 roughly corresponds to a guns-and-butter effort to engage in the Viet Nam war abroad and the War on Poverty at home. The period 1969 to 1973 was one of internal stress as resistance to the war increased and mounting inflation signalled the country's inability to wage war on both fronts. The years 1974 to 1981 saw increasing foreign competition, double-digit inflation and a stagnating economy. As noted in the following statistics, average annual productivity growth declined precipitously during this latter period.

Years	Average Annual Productivity Growth
48-58	3.1%
59-68	3.3%
69-73	2.1%
74-81	0.7%

Source: Bureau of Labor Statistics data.

For the period 1974 through 1981, productivity exhibited an absolute decline in four out of the eight years. For three consecutive years, the average American worker produced less per hour worked at the end of the year than at the beginning.

Examination of outputs and hours employed as separate components provides additional insight into the productivity decay.

Years	Average Annual Growth in Outputs	Average Annual Growth in Hours
48-58	3.2%	-0.1%
59-68	4.6%	1.4%
69-73	3.7%	1.5%
74-80	2.2%	1.6%

Source: Bureau of Labor Statistics data

Rate of growth in output peaked during the period 1959-68 and then exhibited a steady decline. In contrast, number of hours employed showed a steady rate of increase from 1959 on. Thus, with outputs growing at a diminishing rate and hours employed growing at an increasing rate, productivity fell accordingly.

The fall in productivity signaled the economy's inability to convert increased hours of employment to corresponding increases in real output. With declining productivity, compensation per hour rose as wages followed price increases.

Average Annual Increase In Compensation Per Hour	
48-58	5.7%
59-68	5.0%
69-73	7.1%
74-80	9.1%

Source: Bureau of Labor Statistics data

Unfortunately for our economic health, as the increase in compensation per hour accelerated, productivity growth stalled. The corresponding disparity between rates of compensation and productivity growth exerted upward pressure on unit labor costs. Examination of available data revealed a dramatic escalation.

<u>Average Annual Increase in Unit Labor Costs</u>

48-58	-	2.4%
59-68	-	1.7%
69-73	-	4.8%
74-80	-	8.5%

Source: Bureau of Labor Staatistics data

With no productivity buffer to absorb increased labor costs, these costs could be expected to be passed on in the form of increased prices. Examination of the Consumer Price Index for the corresponding period showed a remarkable correspondence between rates of increase in prices and labor costs.

<u>Average Annual Rate of Increase of the Consumer Price Index (CPI)</u>

48-58	-	2.4%
59-68	-	1.9%
69-73	-	5.0%
74-80	-	9.3%

Source: Bureau of Labor Statistics data

Increasing prices cause corresponding pressures for wage increases which, in the absence of sufficient productivity gains, are translated into another round of corresponding price increases. Unfortunately, increases in worker compensation in a period of rising prices result in negligible gains in real wages. Without corresponding gains in productivity, the real return to factors of production can be expected to continually erode.

The United States is not alone in its productivity dilemma. Comparison of productivity trends for other major industrial nations shows the same downward pressures.

Average Annual Productivity Rates

Country	1960-73	1973-80
United States	3.4%	1.3%
Canada	4.7%	1.5%
Japan	10.5%	6.4%
France	5.8%	4.4%
West Germany	5.5%	4.5%
United Kingdom	4.3%	1.6%
Italy	7.3%	3.8%

Source: Recent Productivity Trends in the U.S. and Japan. Bureau of Labor Statistics, 1982.

Although the United States is currently experiencing the slowest rate of productivity growth of the major industrialized nations, it remains the leader in absolute productivity. Relative productivity for the major industrial countries using the United States as a standard indicates that the United States has the lead position, but that other countries are closing rapidly.

Country	Relative Productivity for 1980
Japan	68.4
West Germany	88.7
Italy	60.6
France	89.4
Canada	92.1
United Kingdom	60.8
United States	100

Source: Bureau of Labor Statistics data reported by the United States Chamber of Commerce, 1982.

Given the continued disparities in the rates of productivity growth, the United States stands a good chance of relinquishing its premiere position in absolute productivity within the next four to six years.

Considering the emerging eminence of Japan, it is worthwhile to compare the relative productivity growth rates of the two countries.

Average Annual Change

Years	Capital Productivity		Labor Productivity		Energy Productivity		Materials Productivity		Multi-Factor Productivity	
	U.S.	Japan	U.S.	Japan	U.S.	Japan	U.S.	Japan	U.S.	Japan
1965-1973	-0.49	-4.0	2.45	11.08	0.05	1.49	-0.13	1.0	0.54	0.79
1974-1978	-1.98	-0.15	1.83	5.42	-0.71	3.27	0.00	1.1	.33	1.43

Source: Recent Productivity Trends in the U.S. and Japan, Bureau of Labor Statistics, 1982

In nearly every comparison, Japan exceeds the United States, both in growth of individual factor productivity as well as total factor productivity growth. An interesting point of comparison is that for both the United States and Japan, capital productivity declined over the period 1965 through 1978. For the United States, this decline in capital productivity accelerated more than four-fold, whereas in Japan the decline in capital productivity decelerated during the period 1974-78.

The intriguing question is how Japan can maintain its industrial momentum with decreasing capital productivity. The answer seems to be that increases in productivity of other factors of production compensate sufficiently so that Japan achieves a small but positive multi-factor productivity increase. The most notable difference between the U.S. and Japan is in the area of labor productivity with the Japanese posting a considerable advantage. Japan has also managed to show an increase in energy productivity during the period 1974-78 in the face of mounting energy shortages. The U.S. during that same period of time experienced declining energy productivity. The U.S. was able to reverse a decline in materials productivity but fell far short of the Japanese record. When compared against the multi-factor productivity, the U.S. experienced a 38 percent decline in comparison with an 81 percent increase for the Japanese economy.

CHAPTER II

TECHNOLOGY AND THE PRODUCTION PROCESS

Technology is the great arbitrator of work. It is technology that specifies how capital goods can be used by workers to convert raw materials into finished products. It is technology that determines the range of human skills and abilities necessary to use the capital goods as production tools. It is technology that specifies the appropriate materials for which the tools can be used and the energy required for their use.

As with productivity, technology is most meaningfully understood within the context of a production system. In this context, technology then can be regarded as the process used by a production system to convert resource inputs into product outputs. The process or rule for translating human and/or physical resources into outputs of goods and services is the essence of what is meant by technology. In economic terms, the process whereby the factors of production (labor, capital, materials and energy) are converted into output is referred to by the economists as the production function and can be expressed as:

Technology = Production Function = F(labor, capital, materials. energy)

Technology, considered as a production function, constrains the way the factors of production combine to produce an output of goods and/or services. For example, technology as process determines the unique contribution of each factor of production with the other factors held constant and determines the impact of substituting one factor for another. Factor substitution occurs when one factor, such as capital is used in increasing amounts as a substitute for another factor such as labor. The important point is that it is the current technology that determines how the factors are interrelated and the relative output contributions of each factor.

Suppose now that an increase in the output of the work system was observed even though all factors of production were held constant. The only way this could occur would be for the production function itself to change. Since technology is equated with the process of production, this is defined as a technological change. Technological change occurs when efficiencies in the production process allow for increased output without the necessity for more input resources to be used. Thus, if a change in output accrues from training workers to work smarter but not harder, then a technological change can be said to occur, provided that the increases resulted from more output per unit of labor expended rather than more units of labor being expended (working harder). In a similar manner, technological change can result from any alteration in the production process that results in more output per unit of factors of production used.

The rate and intensity of technological change is determined by the product development cycle. As technical knowledge produced by research and development makes new products possible, firms seek to find markets where these products will fill a designated need. In the early stages of market development, firms seek to maintain flexibility in their productive processes to allow for product alterations that will better serve market demands and improve the firm's competitive position. Flexibility in the production process is sought to enable firms to modify the product or to produce a mix of similar products in those cases of specialized demand. The best example of production geared for product flexibility is that of the "job shop." This operation is set up to enable rapid shifts of the production process to produce a variety of products upon demand. At the extreme is the custom shop which may have the productive flexibility to produce a completely unique product.

As demand for the product increases, firms are forced to make a trade-off between flexibility and efficiency. To maintain competitive pricing, increased numbers of products will have to be produced and production efficiencies realized in order to lower unit product costs. Since there are fixed costs associated with setting up, scheduling and materials handling, larger production runs are required to absorb these costs. Longer production runs make it more feasible for companies to acquire more specialized pieces of equipment. This specialization, in the quest for more cost-effective technology, serves to reduce productive flexibility and lock the firm more closely with specific product lines and associated technologies. For those high volume demand products, the natural progression of technological change is towards hard automation of the production process and continuous production flows. As the technology solidifies into a continuous production process, the firm's capabilities to shift products diminishes markedly as it becomes increasingly more expensive to change the institutionalized technology. Increased investments in fixed capital in the form of dedicated machinery and equipment result in highly efficient, but extremely inflexible production technology. This explains why it is estimated that expenditures in the neighborhood of $150 billion will be required to increase the fuel economy of U.S. cars to levels expected by 1990 (National Productivity Review, Winter, 1981-82).

Periodically, significant advances in knowledge are achieved and embodied either in the form of new materials or capital goods. Typical examples are rayon, which was first introduced as a light filament; the transistor, which initiated the electronics boom; and the jet aircraft engine, which has replaced piston engines in commercial aviation. These product innovations represent such a drastic departure from conventional modes that organizations, in order to survive, must alter their technology. Production functions that differ in form are termed technological innovations, and are to be differentiated from technological changes. Whereas technological change is associated with incremental evolutionary changes in the production function and format, technological innovation signals a discrete shift from one form of production function to another. These dramatic shifts in technology serve both to create new business and to undermine existing investments. New firms spring up as market niches are created by increasing applications of the process innovations. Established product lines are threatened and eventually forced to give ground as the new technology becomes increasingly widely used. According to German economist Gerhardt Mensch, innovations appear in bursts. The reason, he explains, is that the innovations lie around on a shelf until there is sufficient venture capital accumulated to develop them into marketable materials and/or products (Wall Street Journal, June 4, 1981). Thus, whereas technological change is evolutionary and tends to be cumulative and focused, technological innovations represent discrete breaks with the past and, as Mr. Mensch argues, tend to occur in clusters throughout history.

MAJOR TECHNOLOGICAL INNOVATIONS

In order to convey the breadth and scope of the stream of technological innovations occurring today, attention will be directed to four major technological innovations that will undoubtedly change the face of American working life. These areas are provided to give a synopsis and are not meant to provide exclusive coverage. For a further description of the technologies that will likely impact vocational education, the reader is referred to the series of papers entitled, "Technologies of the '80s: Their Impact on Vocational Education" (CONSERVA, Inc., 1982). Technologies with significant impact for major vocational education program areas are identified and their training implications discussed.

Microprocessors

Microprocessors have been assigned to the lofty status of the wheel, the combustion engine, and the light bulb as inventions that have revolutionized society. The microprocessor has as its heart the micro chip, a tiny piece of silicon with etched circuitry that can perform the work of a hundred thousand vacuum tubes. These chips provide the computer logic circuitry that enables the mass production of machine intelligence and its application to a variety of commercial and consumer uses. Microprocessors have found application in such diverse uses as process controllers on industrial steam boilers, regulation of automobile engine performance, transference of typewriters into highly sophisticated word processors, controls for aiding ventilation and air conditioning systems, controlling cutting heights and auger speeds in agricultural equipment, provision of automatic stitch control in sewing machines, separation of signal from noise in home stereo systems and an untold variety of other applications. Microcomputers, made possible by micro chip innovations, have dramatically expanded information processing capabilities. In business, microcomputers are used for such tasks as inventory control, payroll, budget allocation, to name but a few. Over 275,000 microcomputers were sold in 1978 with more than 1.2 million anticipated to be sold in 1982 (The Futurist, August, 1981, page 6). Future developments include the nano processor, which is a thousand times more powerful than the microprocessor and expected to be available within a decade. Following that is the pico processor, which is reported to be one million times more powerful than our current units. The stage is set for a technological explosion, the effects of which can barely be conceived.

Robotics

The robots are coming and coming to such an extent that they may create a new class of job--the steel-collar job. A far cry from the humanized form of Hollywood movies, the industrial robot is essentially a mechanical arm, fitted with a variety of fasteners and programmed to reproduce repetitive motion cycles. The Robot Institute of America defines a robot as

> a reprogrammable, multi-functional manipulator designed to move materials, parts, tools or specialized devices . . . through variable programmed motions for the performance of a variety of tasks. (RIA News, Robotics Today, Spring, 1980, page 7).

The key factors that differentiate a robot from other special purpose fixed type automation is that robots are considered to be reprogrammable, multi-functional, and variably programmed to perform a variety of tasks. Robots are currently in use in a wide variety of industrial jobs including spot welding, spray painting, die casting, loading and unloading machine tools, stacking items on pallets and other strictly repetitive tasks. Robots are best utilized in those tasks where repetitive work motions are required and where objects to be manipulated occupy fixed positions in the workplace. However, robots with rudimentary sensing and feeling capabilities are currently being employed on a limited basis and may be expected to take on a broader range of industrial tasks within the next decade.

Currently there are some 4100 robots in use in the United States (INC., June, 1982, page 68). According to some experts, by 1990 there may be as many as 120,000 robots in use in the United States (The Wall Street Journal, October 26, 1981). There are currently over 30 U.S. companies producing industrial robots. Sales have climbed from $35.5 million in 1978 to $155.5 million in 1981. By 1990, robot sales are expected to exceed $1 billion. Robots are prized because they can work faster than humans and at a cost of less than $6 an hour. Besides that, they can work three shifts a day, require no lunch nor coffee breaks, are easily retrainable, and have an insatiable appetite for work.

CAD/CAM Manufacturing Systems

CAD/CAM is short for computer-assisted design (CAD) and computer-assisted manufacture (CAM). The essence of a CAD system is the use of a computer to perform the design functions. Through the aid of computer graphics, a design of a product or a part is projected in a perspective drawing on the computer screen. The designer can call for different orthographic projections and the computer will display them upon command. In addition to the flexibility provided to view the part from different perspectives--up, down, sideways--the system allows the designer flexibility to change a line contour or other aspects of the design and then to view the total design implications of this change. In addition to augmenting the graphic capabilities of the designer, CAD systems also enhance the design evaluation function by computing a variety of functions used to assess design efficiencies such as stress factors, weight, metal traits, heat characteristics, drag coefficients, and so forth. Once a design is selected, CAD systems facilitate parts planning by providing a takeoff list of all component parts needed to produce the design as drawn. This capability materially decreases the time spent from the design of a product to parts specification and materials planning stages.

Computer-assisted manufacture (CAM) refers to the use of computers to control and/or coordinate metalworking machinery such as drills, mills, lathes, punches, and machining centers. A program is prepared which designates fixtures, cutting tools and feeds and speeds which are converted into general cutter path instructions. There is nothing particularly new in using a computer to perform these functions. What is innovative, however, is the linkage with the CAD system. In this manner, the computer program for machining the part is produced directly from the graphic design without the necessity of first converting to punch tape as has been previously required. Thus, the CAD/ CAM system has linked, through the vehicle of the computer, the design and machining function with substantial improvements in performance efficiencies.

As a further innovation, computer-controlled metalworking machines can be organized into machining centers and a robot utilized to transfer finished products from one machine to the other. It is but a short step to the integration of these machining centers into a total computer-controlled manufacturing process. What is needed is a centralized buffer storage, a robotized materials handling system and a central computer facility to control the manufacturing process. The central computer would control the manufacturing process by establishing the processing parameters, would record production data, turn machines on and off, schedule the production runs and designate what changes in machine tools would be required. All this could be theoretically accomplished without the presence of a single human being. Fully automated plants are within the capability of today's technologies. Cincinnati Milacron has a fully automated injection molding plant on its drawing boards and anticipates that by 1990 software for a peopleless plastics plant will be routine (Plastics Technology, September 19, 1981, page 74). The planning costs, due to improved computer technology, will make feasible tomorrow what cannot be justified by today's economics.

The Office of the Future

Technology has come to the office. Rising office costs, escalating at an estimated rate of 12 to 15 percent per year, are making gains in office productivity imperative. Unless efforts are made to contain office costs, firms run the risk of losing in the office the gains that they have made on the production floor. As with other areas, computers have made and will continue to make substantial inroads into improving office productivity. Addition of storage space and a micro-processor control have converted typewriters into word processors. Written material can be inputted, brought up on the screen, edited and revised without the necessity of re-keying. Word processors are now being connected via telecommunications into increasingly sophisticated communication networks with materials being passed electronically from one processor to another. Electronic mail now permits messages to be placed in an electronic mail box and the computer used to retrieve these messages upon command. Micrographics--the process of transferring computer output directly to microforms without the necessity of printed outputs is the first significant step toward a paperless office. Computer-aided retrieval (CAR) is facilitating the storage of data on microforms since the computer can be used to locate specific documents. Improved interfaces have allowed word processors to be connected to photocomposition equipment and material to be transmitted without the need for re-keying. Materials can flow directly from the word processor to a communicating copier and hard copy can be made directly. Telecommunication networks will soon make possible the interlinkage of all personnel, thereby reducing the necessity for dealing with individual pieces of paper. By substituting electronics for paper as the medium of communication, a substantial contribution to rising office costs can be eliminated.

SKILLS IMPLICATION

These and other technological innovations on the horizon will drastically alter the current patterns of skills requirements. The automated workplace will offer little opportunity for those who do not have the necessary knowledges and skills. New and emerging technologies are shifting the emphasis from manual to mental skills. Instead of 'hands-on' experience, the new technologies will necessitate 'heads-in ability.' Well-trained hands will pale in importance as the emphasis shifts to well-trained minds.

The range of occupations influenced will be monumental. The accelerated shift to more automated work processes is expected to influence some 45 million jobs--nearly half of the labor force in the near future. It is within the realm of distinct possibility that robots could replace 4 million jobs out of a current 19.7 million before the turn of the century (National Productivity Review, Winter 81-82, page 54).

Production magazine conducted a delphi survey of experts knowledgeable in production management. Their consensus was that by 1990, 80 percent of in-process and finished inventory would be computer controlled with programmable devices replacing 50 percent of direct labor in many applications. These experts went on to speculate that current technological innovations would require about 50 percent of the work force on the shop floor to be engineers or technicians (Production, April 1980, page 81). The skills requirements of machinists were projected to be reduced because of increased skills being designed into computer-controlled machines. An understanding of computers was considered necessary in order to work with microprocessor-controlled machinery. Maintenance personnel were anticipated to require a greater familiarity with computers and electronics. Skills levels were expected to diminish due to increased use of modular components where repair would consist of making a black box change. Tool and die-making was seen as requiring more math, physics and chemistry background, with workers being more skilled in decision making and problem solving than current job incumbents. Future tool and die makers will be regarded more as technicians than as production employees.

Adoption of technological innovations will have both a direct and an indirect impact on human skills requirements. The net effect of most technological advancements is to incorporate operator skills into the equipment design. This tendency is materially escalated by the increasingly rapid introduction of smart machines. These machines are smart in the sense that they have the capacity for improved monitoring, processing of information and decision making. Automation of existing jobs means that these functions are increasingly being transferred to machines with the resulting de-skilling of the job for the human operator. In some instances, capital is used as a complete substitute for labor as in the case where a robot welder replaces a human welder.

Not only does technology influence the job content and correspondingly the job skills, but also the workplace organization as well. By changing the skills mix of various jobs, technology alters status, power and communication relationships which are the cement that holds organizations together. A typical example is provided by the introduction of electronic switching systems in central telephone offices.

Instead of switching calls by electro-mechanical process, telephone calls are switched electronically. The process is controlled by a central computer that directs telephone traffic at a rate of 150 calls per second. The process is largely self-monitoring with computers doing much of the troubleshooting and diagnostic work. Since there are no moving parts, there is no need for mechanical repair service. Increased efficiencies make it possible to do the same amount of work with half as many people. Whereas the job was traditionally performed with skill-switching technicians who had a great deal of local autonomy and mobility, computers have transformed the job into monitoring a video screen. The monitoring and repair functions of the switching technician have been centralized and as a consequence, the technicians operate from banks of video display terminals by which they keep watch over the system. Technicians' jobs have been downgraded to the extent that many of them no longer fix malfunctioning lines themselves, but rather spend their days monitoring the computer screen. Work assignments are received over the video screen and as each technician completes his/her work, the time taken to complete the work is entered into the terminal. As a result of the technology, the total workplace has been transformed with the previous autonomy of switching technicians being replaced by rows of computer operators locked to their terminals (Working Papers, November/December 1980).

Others see a brighter picture. Telecommunication networking allows computers to be dispersed across greater distances. The ability to perform work without the necessity of being in close physical proximity has the potential of altering the entire employment function. Instead of firms having employees, their relationship could shift to that of contracted employment where workers contract to perform those tasks and duties for which they have the most skills, interest and abilities. This increased flexibility made possible by the computer and the capability to address central data banks from remote locations has the possibility to alter the organization of work as we now know it. Work performed by a myriad of independent contractors would require a totally different organizational structure and make the current concept of supervision and motivation obsolete. Whether the computer will ultimately result in work organizations that permit greater human freedom and dignity, or whether they will create more demanding, intensified and stress burdening jobs remains for the future to resolve.

While technology frequently has the direct effect of de-skilling jobs, the indirect effect is to create new jobs with higher skills requirements. As Eli S. Lustgarten, a student of industrial robotization, puts it:

> Retraining is the major social problem created by rapid robotization, not unemployment. The jobs created by widespread use of robots and unmanned manufacturing--programmers, technicians, engineers--for the most part require a high degree of technical training. Massive training programs will be needed to prevent the creation of an oversupply of workers whose skills have become obsolete and simultanteous shortages of engineers and technicians (The Washington Post, Friday, January 7, 1982, D-10).

The initial effect of new technology is to have the technical aspects performed by engineers. As the technology becomes more widespread, the demand for technical skills increases, and engineering shortages escalate, the responsibilities will shift to technicians.

Thus technology will tend to have a wedge effect on the distribution of job skills. Some skills will be displaced downward, resulting from the assumption of skilled operator tasks by the machine. New skills requirements created by the introduction of the technology will generally be at the engineering and technician levels. Greater premiums will be placed on mathematics, science, and computer programming knowledges and the ability to apply these knowledges in diagnostic and problem-solving situations necessary to extend the technology to creative applications.

CHAPTER III

EXTERNAL FORCES TO BE RECKONED WITH

The outcome of the quest for productivity gains will be decided on the shop floor and at office desks. The extent to which quality resources are available and a management climate in place that is supportive of their use will make the critical difference. Vocational education can neither perform the work directly nor can it ensure the existence of a favorable management climate. Vocational education can, however, play a significant role as an intermediary. In this role, vocational education can exert an important influence on both the quantity and quality of human capital. Vocational education can impact upon management climate through the training of future managers, and supervisors and workers and by serving in a consultive capacity to present management.

Facilitation of productivity through an intermediary role requires that vocational education be cognizant of forces impacting on our current productivity position. Many of these forces are the aggregate results of individual worker and managerial actions. These individual actions collectively cumulate and swell to the level of a major force for change. Since these forces emanated from individual actions, they can ultimately be controlled by individual acts. It is the responsibility of vocational education to understand the nature of these forces for change and to intervene at the grassroots level to alter their course. It is the purpose of this chapter to examine some of these major forces and to explore their significance for productivity improvement.

THE THIRST FOR CAPITAL

There is near universal agreement that the lack of capital has been one of the major causes of productivity decline. As Lester Thurow, a noted expert on productivity states,

> The amount of equipment per worker--the capital-labor ratio--is a key ingredient in productivity growth. Better-equipped workers can produce more output per hour, but new capital is also a carrier of new technologies. To put new, more productive technologies to work, workers must be provided with the equipment that embodies these new technologies. Without this additional hardware, or 'physical capital' it is impossible to translate new knowledge into new input (Technology Review, November/December 1980, page 45).

A measure of capital available to the employed work force is provided by the capital-labor ratio. This ratio indicates the amount of net capital per employed worker. Other things being equal, a rapidly rising rate in the capital-labor ratio indicates increased capital investments in new technology and automation which should be expected to result in productivity gains. When analyzed over the same four time periods used to assess productivity performance, average annual rates of increase in capital-labor capital ratio show the same downward tendencies.

Average Annual Increase in the Capital-Labor Ratio

Years		
48-58	-	3.4%
59-68	-	2.1%
69-73	-	2.6%
74-80	-	1.3%

Source: U.S. Department of Commerce data as reported in the United States Chamber of Commerce Statement on Productivity, op. cit., 1982.

As a result of its definition, changes in the capital-labor ratio can be due to changes in capital investment and/or in the numbers of employed workers. Examination of the data indicates:

Years	Average Annual Growth Rate of Real Net Capital Stock	Average Annual Increase in Employment
48-58	4.5%	.4%
59-68	4.3%	1.6%
69-73	4.4%	2.0%
74-80	3.2%	2.2%

Source: U.S. Department of Commerce and U.S. Department of Labor, 1982.

As shown, the rate of net capital formation has dropped significantly since 1974. Several explanations can be offered. Increases in the purchase price have made new capital relatively more expensive and have acted to encourage the substitution of labor for capital. The purchase price of new capital equipment relative to wages and fringe benefits decreased only 0.7 percent per year during the period 1972-78 in comparison with a 2.7 percent per year drop from 1948 to 1965 (Thurow, 1980). A second factor accounting for a drop in capital investment is the surge in energy prices that occurred during this period. Throughout most of the industrial development of America, capital had been substituted for labor in increasing amounts as evidenced by a steady rise in the capital-labor ratio. Energy shortages, however, have served to curtail pressure on capital expansion. Since capital requires large amounts of energy, rising energy costs have made capital more costly. As a result, the rate at which new capital has been acquired has declined.

While net capital investment grew at a constant and then declining rate, the rate of work force growth increased more than fivefold. The implication was not that Americans were not investing, but simply that they were not investing rapidly enough to equip each new worker added to the work force with a constant share of capital. Energy shortages, by making capital more expensive, have contributed to the acceleration of work force growth. As Dale Jorgenson, Harvard University economist argues, rising energy prices cause producers to cut back on amount of capital. Because energy and labor appeared to be fairly good substitutes, rising energy prices tend to increase the demand for labor (Business Week, June 1, 1981).

Restricted growth in the formulation of new capital has an impact on the quality of existing capital. Statistics indicate that the average age of plant and equipment in the United States is 16-17 years in comparison to 12 years in West Germany and 10 years in Japan (Congressional Hearings, November 4, 1981). In a survey of the U.S. stock of machine tools, Productivity magazine (January 1980) found that 34 percent of the United States' stock was over 20 years old while only 31 percent was less than 10 years old. This compared with Japan which had 18 percent over 20 years old and 61 percent of their stock under 10 years old.

Savings represent a significant source for investment funds. However, America tends to be a consumption-oriented society with less proclivity to invest in long-term capital acquisitions. Americans save barely 5 percent of the Gross National Product in comparison with the Japanese who save nearly 1/3 of their Gross National Product each year. Whereas Americans tend to invest about 11 percent of their Gross National Product in nonresidental fixed investments, the Japanese invest on the average a quarter of their annual Gross National Product in the private sector (Congressional Hearings, November 4, 1981). Inflation and easy credit has conditioned the American buyer to consume now and pay later with dollars of diminished purchasing power.

FOREIGN TRADE--OUR SHRINKING SHARE

In the area of foreign trade, the United States is in the process of moving from being a net exporter to a net importer in major categories of industrial output. As shown by a study recently conducted by the Department of Labor of the top 17 U.S. export commodities, losses in the world market were experienced in 14 of the commodities between 1962 and 1979. By 1979, the U.S. trade position had deteriorated such that market losses had been experienced in all 17 of the top export commodities. (Congressional Hearings, December 1980 and January 1981). The report attributed the decline in U.S. international competitiveness to changing supplies of world resources and diminished technological capabilities. The rate of growth of the capital-labor ratio, a measure of the amount of capital available per worker, declined to such an extent that the United States fell from first to sixth in terms of capital available per worker. The United States' share of world capital fell from 42 percent in 1963 to 33 percent in 1975. During the same time, Japan doubled its capital from 7 to 15 percent of the world's share. As the U.S. stock of physical capital fell, so did its human capital. According to Department of Labor analyses, the United States fell from second to seventh in terms of percentage of skilled workers in the labor force--with the U.S. share of skilled workers falling from 29 percent to 26 percent. (Congressional Hearings, December 1980 and January 1981).

In addition to competition from the major industrialized nations of the world, the United States is experiencing competition from the rapid industrialization taking place in developing Third World countries. More and more products are coming into this country with the label: Made in Braz 1, Mexico, Taiwan, South Korea, Singapore, India, or a host of other nations. Some of these nations, particularly Brazil, Mexico and India have a broadly diversified industrial base and are showing strong competition with the United States in the areas of textiles, apparel, shoes, standardized consumer electronics, steel products, standardized machinery, ships and automotive components (Hill and Utterback, 1979). Many of the developing Third World countries have a large pool of unskilled and semi-skilled labor willing to work at a fraction of the wages paid in the United States. The result is that these countries have a competitive advantage in products that are highly labor intensive. Because of this competitive advantage and in the absence of imposed trade barriers, these countries are and will continue to capture a growing share of the world market including the U.S. domestic market. In recognition of this advantage, many U.S. companies are moving their production capacities offshore to take advantage of lower labor costs. The obvious result is to reduce the opportunities for American workers. Because of the nature of the skills being withdrawn, these lost opportunity costs will fall most heavily upon the disadvantaged, minorities and women.

A SEGMENTED ECONOMY

The American economy is frequently referred to as though it were a single unitary entity. This notion is reinforced by references to the singularity of the economy in terms of economic growth, needs and outputs. In a classic example of informed journalism, Business Week persuasively argues that whereas there is one country, there are five separate economies each with different growth of outputs, employment, investments and profits and each being driven by separate forces and running according to new rules (Business Week, June 1, 1981, pp. 56-59). The five sectors of the segmented economy are represented by energy, agriculture, high technology, services, and old-line industries. Segmentation was projected to be a continuing condition with the sectors competing for increasingly scarce resources and survival depending upon their competitive advantages. Those firms that were in a position to reduce their energy costs will be in a favored position. Firms will increasingly turn to capital as a means of improving their cost position. There will be prolonged periods of capital shortage with capital shifting from the low growth sectors to those that promise more return.

Not all sectors will emerge from the decade of the '80s as winners. High technology is in a favored position and is projected to be ". . . the unquestioned leader in growth of real output, productivity and employment . . . ." (Business Week, op. cit., p. 74). The quest for new and approved technologies is expected to be relentless as firms seek improved cost positions.

The service sector will shine in the 1980s as services move to the forefront of economic activities. In 1950, nearly one out of three non-agricultural workers was employed in manufacturing, and only one out of eight employed in services. By 1980, only 22 percent of the non-agriculture workforce was in manufacturing as opposed to nearly 20 percent in services. In terms of percent change in employment for the three-decade period, manufacturing increased a scant 33 percent in contrast to the 233 percent increase for services (Riche, October 1981). The shift is being experienced both in international as well as domestic markets. While we are becoming a large net importer of manufactured goods, the United States now exports about $60 billion worth of services a year. This qualifies the United States as the largest exporter of services in the world, exporting nearly 25 percent of the world's service base (Presentation of Dr. David L. Birch to the Council of Upper Great Lakes Governors, March 5, 1982). Services have an important but little-noticed role in goods-producing activities. It has been estimated that this massive hidden service sector accounts for more than 3 million of the 3.6 million increase in total manufacturing jobs from 1948 to 1978 (Business Week, op. cit., page 82). This large hidden service component results from the large number of occupations that do not directly involve production, i.e., computer programmers, maintenance engineers, management, security, and a host of others. A growing tendency will be for goods producing firms to farm out responsibility for their service activities. Companies specializing in such activities as food services, security, janitorial services, and other business services are expected to thrive and to increase the productivity of the service sector by increased use of management techniques such as scheduling, inventory control and other managerial skills augmented through the use of computers. Data Resources, Inc. predicts that the biggest growth areas in services will occur in air carriers and related services, motor freight, real estate, business services, hotels and lodging places, printing trade services, radio and T.V. broadcasting, water transportation and related services and residential maintenance and repair. Taken together, the service sector will provide much of the economic impetus with two out of every three employed Americans working in a service-related capacity (Business Week, op. cit., p. 95).

The more mature industries--those industries that once used to be the mainstay of the American economy--are facing a bleak future. Manufacturing now employs less than 1/3 of the non-farm workforce. Many plants stand idle or are running from 70 to 80 percent capacity. Investment is growing but output per investment dollar is shrinking due to a declining growth in output. In an effort to reverse the trend, basic manufacturing is undergoing a massive reorganization. Obsolete equipment is being replaced and antique plants being closed. Since 1973, 23 U.S. tire plants have closed (Business Week, op. cit., page 86). Manufacturing industries are divesting themselves of holdings acquired during the acquisition-oriented period of the 70s. To overcome their low growth potential, basic industries are turning to labor-saving equipment and are making substantial capital investments. Since 1970, textile manufacturers have invested some $11 billion in capital improvements such as new plants, technology, robots and computers, with the investment in 1981 topping the $1.6 billion mark. As a result, productivity has increased in the textile industry at a rate four times faster than the national average (Plastics Technology, September, 1981, page 71).

Sectorial differences in growth are also related to regional geographic location. Basic manufacturing industries are located in the northeast crescent anchored by St. Louis on one end and Boston on the other. The fact that not all sectors of the economy are equally represented in all geographic locations will have significant repercussions on the regional distribution of jobs, capital and income. Employment growth by regions differs substantially. Job growth for the Rocky Mountain and Southwest regions is projected to grow by some 35 and 31 percent, respectively, in comparison with a 15 percent growth for New England and less than 11 percent growth for the Mideast section of the country. The differences are even more pronounced when compared on a state-by-state basis. Employment in Wyoming is projected to experience a 45 percent growth rate during the decade of the 80s and Texas a 30 percent growth rate in comparison with 11 percent projected for Pennsylvania and less than 6 percent for New York State. Of the 13 states expected to experience the greatest absolute increase in employment over the 1978-1990 period, three states--California, Texas and Florida--account for nearly 50 percent of the employment growth in these top-ranked states. One out of every four new jobs to be created in this country during this decade can be expected to be located in either Texas or California. One out of every ten jobs will be in Texas alone (Congressional Record-Senate November 12, 1981). During the decade of the 70s, factory jobs in the Northeast and the Midwest declined while increasing by 25 percent in the South and West (Business Week, op. cit., p. 62). This trend was paralleled by construction which showed less than a 3 percent increase in the Northeast and Midwest as opposed to a whopping 55 percent increase for the South and West. The same disparity holds for capital which was being accumulated at a rate 2-1/2 times faster in the South and West than in the Northeast and Midwest. This lagging capital growth means an increasing amount of aging capital in these regions that will further hinder productivity, resulting in higher unit labor costs and shrinking profits.

Regional differences in taxes, energy costs, and labor costs give the South and West a comparative cost advantage and make location in these regions more attractive to industry. Greater economic activity in the South and West is predicted to generate regional differences in real income. In comparison with a projected U.S. growth rate of 2.8 percent for the decade of the 80s, the South and West are projected to grow at 3.2 percent in comparison with a 2.4 percent projected growth for the Northeast and Midwest (Business Week, op. cit., page 64). The disparity in income growth will not be distributed equally over all segments of the population. Blacks and other minorities are more heavily concentrated in the large metropolitan areas of the Northeast and Midwest. Reduced income in these regions will result in less taxes available to support public education and other public services. Reforms in federal tax laws to promote capital expenditures will result in less revenue from corporate taxes going into the state coffers. In contrast, income generated from energy-related investments provides a steady stream of revenue for the oil-rich southwestern states.

THE JOB CREATION PROCESS

The process whereby new jobs are created has been studied extensively by MIT economist David Birch. Based upon his study of some 5.6 million businesses, he concluded that jobs turn over at the average rate of 8 percent per year and businesses at an average rate of 10 percent per year. This turnover rate seems to be remarkably constant across geographic locations. According to Dr. Birch, ". . . every five years every place in the country has to replace about 50 percent of its job base" (Birch, March 5, 1982, op. cit.).

Nearly nine out of every ten jobs created were in the area of service occupations. Less than one job out of every eight jobs created in the 70s was in goods production. Small firms were much more active than larger firms in replacing those jobs lost in the turnover process. Firms with 20 or less employees created nearly two-thirds of the job opportunities, with most of the new jobs being created by young firms.

The implication is that job creation is basically a birth-death process, characterized by rather rapid turnover. The fact that small companies account for the vast majority of new jobs supports the contention that small companies are greater risk takers and are seeking to create a market niche that will support their existence. However, small companies have greater problems in attracting venture capital and often experience greater cash flow problems, thereby making their existence more perilous and increasing their likelihood of failure. The continuation of the formation of new jobs in the face of rising business failures attests to the tenacity of the American entrepreneurial spirit.

LABOR SHORTAGES

As a compounding problem, the United States is reported to be experiencing a severe shortage in skilled labor. In a widely quoted report, the Department of Labor projects average annual training shortfalls in excess of 250,000 persons per year for the next decade (U.S. Department of Labor, 1981). These are regarded as minimum estimates since they result from inclusion of only the 13 occupations with the greatest projected shortages. The Task Force on the Skilled Trade Shortages, which represents a coalition of 13 metalworking industries, estimates an anticipated need for 240,000 journeyworkers in the metal trades by 1985. (American's Skilled Trade Shortage: A Positive Response, 1981). The American Electronics Association, in a survey of its members, projects a need over the next five years for approximately 113,000 technical professionals in eight job categories and an additional 140,000 technical paraprofessionals in 13 job categories. (Congressional Hearings, November 3, 1981).

The implications of a serious shortage of skilled labor for our defense capabilities was reported on by the Defense Industrial Base Panel of the Committee of the Armed Services (House of Representatives, December 31, 1980). The Panel expressed considerable concern regarding the lack of a base of skilled manpower to support a defense industrial base. The use of offshore labor in such critical defense industries as semi-conductors was found to be "troublesome." Because of increased technological complexities required in defense production, farmers, clerks and housewives could not be recruited in a matter of weeks and trained to work in defense production. Lack of transference from civilian to military high technology manufacture and the times required for retraining were given to refute the argument that if we geared up for World War II by training "Rosie the Riveter," we could do it again.

MANAGEMENT CLIMATE

In addition to the previous forces, there is a growing concern that management itself must share a major responsibility for the declining productivity of this country. As Secretary of Commerce Malcolm Baldridge told a group of senior business executives, economists and labor leaders at the first meeting of the National Productivity Advisory Committee, "We've got to get our managers back into entrepreneurial thinking and away from financial reports, or into research and development and less 'Let's get the product out of the door.'" (The Washington Post, January 7, 1982).

How then does management hinder productivity? The answers are emerging slowly--in part assisted by a comparison with the Japanese style of management. A concern for productivity and a focus on the internal work processes have not been popular management topics. Rather than concentrating on production management, American managers have tended to place more emphasis on external factors such as market penetration, market share, and overall return on investment. By focusing on the big picture, there is a growing consensus that management may be losing sight of the importance of people. As H. Ross Perot, Chairman of Electronic Data Systems, states, "It's the people in the first-line jobs that make or break a company. Lose them and you're out of business" (Government Executive, June 1981).

American management has been criticized for being preoccupied with short-run concerns. Organizational performance tends to be judged according to the quarterly financial statement and investment options evaluated in terms of annual or biannual payback returns. This emphasis on short-run optimization has reduced the capacity of management to assume risks associated with long-run capital ventures.

James O'Toole in his recent book entitled Making America Work (1981) argues that a restrictive management culture has evolved that stifles productive endeavors. Restrictive management cultures, according to O'Toole, are characterized by a rigid adherence to formal norms and practices even though they may interfere with more productive work organization. Restrictive cultures tend to be closed to new ideas, resistant to change and characterized by distant and formal personal relations. Decision-making tends to be authoritarian; the organizational climate is one of distrust and suspicion; employee participation in work decisions is minimal; and adherence to procedure more important than quality of the final product. Admittedly, these characteristics represent the extreme of organizational bureaucracy. They are, however, useful in communicating those management characteristics that are considered detrimental to productivity improvement.

Howard J. Samuels, a productivity consultant, in testimony before Congress supports the contention that management practices are inhibiting productivity growth. According to Samuels,

> Experience of over a decade of productivity consulting indicates that the adoption of more efficient management techniques can improve private sector productivity by a minimum of 10-20 percent without any additional capital spending on technical innovations. (Congressional Hearings, January 27, 1982).

CHAPTER IV

INTERVENTION STRATEGIES

WHAT IS THE MESSAGE?

If any message comes through, it is that America stands at an economic crossroads. In the face of impending labor shortages, American business and industry can follow one of two major courses--one will be business as usual. If that philosophy prevails and a labor shortage materializes, per unit labor costs can be expected to increase, leading to increased prices as business seeks to maintain its profit picture. Continued sluggishness in capital investments, coupled with a shortage of skilled labor, will dim many prospects for productivity improvements. As a result, inflation can be expected to escalate, our standard of living to diminish, our foreign competition to increase and the United States will be well on its way to becoming a second-rate power.

As an alternative, the United States can make a significant investment in labor-saving capital in an effort to reverse the productivity trends and to regain the competitive edge. If the strategy is undertaken with vigor, the implications can be profound. Unlike the early 60s when the concern for the effects of technology proved to be unfounded, the United States currently stands on the brink of a technological revolution drawing its force from the emergence of the microprocessor and its ubiquitous applications. Second generation industrial robots with sensing capabilities could perform over 40 percent of the operative jobs in metalworking. Within the next two decades, 4 million jobs out of a current 19.7 million manufacturing jobs could be robotized.

Technological advancements will revolutionalize office procedures and make the video screen the new "tabla rosa," replacing paper as the communication medium. The restructuring of the American economy will see poverty in the midst of plenty as the various sectors compete for labor and capital and seek to maintain competitive differentials based on cost, price or service. In an effort to reduce risk, the larger companies can be expected to narrow their focus and concentrate on product lines in which they have accumulated experiences.

The flipside of a conservative market strategy will be to launch an effort to cut production costs through productivity increases. Capital will be replaced, not on the basis of how much life remains in the equipment, but rather on how much it costs to keep it in operation as opposed to replacements by new technologies. Companies will seek to maintain a vibrant market position by availing themselves of the advantages of new technologies. Small companies will remain the most innovative and will assume the largest risks by venturing into unknown market areas.

What, then, is the significance for vocational education? If there is any lesson, it is that vocational education cannot itself remain static in the midst of a struggling economy seeking to find itself without running the risk of the judgement that "I called and you failed to answer."

Vocational education's responsibility is to assure that the nation remains true to the principle that work is for man and that labor cannot and must not be subjugated to capital in the production equation. Vocational education must seek to overcome the perception that employees can no longer be relied upon to improve our nation's productivity. This is the viewpoint articulated by Russell Hedden, Chief Executive Officer of the Cross and Trecker Corporation, who advances the view that

> For every employee who is sincerely attempting to produce to his or her maximum level, we see another employee who has no desire to perform above the level needed to remain on the payroll. For this reason, although I am a proponent of realistic employee motivation techniques, I do believe we must accept the postulate that future increases in productivity will come about primarily from investment in improved equipment rather than from reliance on personal zeal . . . If we accept this postulate, we must come to grips with the need to produce and install more sophisticated machines throughout the country; machines that will give us increased capability to improve the nation's productivity. We must also increase our R&D programs to develop a greater proportion of new, high-productivity machines to older, less-productivity productive equipment (Production Engineering, September 1979, page 93).

Given this challenge, the question is how does vocational education respond. Vocational education, to meet the needs of a restructuring economy, must be prepared to restructure its own organization to meet the demands of the changing times.

Central to this restructuring is the requirement that vocational education turn its attention to the development of vocational generalists. The job-shop model in which vocational education sought to recreate the job conditions and provide the opportunity for learning through "hands-on" experience is becoming obsolete. Rapid technological innovations in the job and office environments make it neither feasible, wise nor possible to import into the classroom. Employers, when questioned, almost universally express the desire to retain control over training of employees with respect to work procedures. This is understandable since employers have their own unique operational requirements and do not wish to incur costs of retraining employees who were taught on obsolete equipment on in situations where the skills do not transfer. Lack of standardization currently experienced in the microprocessing industry and certain to characterize robotics and other applications, precludes the learning of one commonly accepted best way.

Instead of trained human capital, employers are seeking trainable employees who can operate in a variety of situations and whose background knowledges and skills will support mastery of activity requirements with minimal training. Employers are becoming increasingly dissatisfied with the capabilities of on-the-job training to impart the basic knowledges and skills necessary to perform across a variety of applications. Increasingly sophisticated technological equipment is making it increasingly more difficult to infer the organizing principles and properties from direct observation and experience. What is developing is a back-to-the-basics movement with regard to technical areas such as mathematics, physics, computer programming, systems applications, and other technical knowledge areas. The emphasis is not upon the learning of these theories and principles per se but upon an understanding of their application in real work settings.

What is being called for, although perhaps by another name, is the application of the apprenticeship model to the teaching of technical skills. The major difference is that where the craftsperson carried a fixed set of tools and possessed the expertise to apply these tools in a variety of situations, the modern equivalent claims knowledge as the tools and professes the ability to apply these basic knowledge tools in the learning of specific production procedures. Because these procedures cannot be specified with precision, the knowledge base must be sufficiently broad to support transference and to facilitate acclimation and orientation to specific job performance requirements.

The shift to a vocational generalist role will circumvent vocational education's increasing difficulty in equipping its shops and laboratories with modern equipment. A recent study concluded that ". . . With the critical lack of funding in this area [equipment acquisition], it is impossible for vocational education to plan and provide programs related to new and emerging technologies" (University of Wisconsin, November 1981). This study surveyed some 200 schools and determined that less than 1 out of 5 schools surveyed reported making some or extensive use of computer-assisted design in existing programs and less than 1 in 20 schools reported making use of robotics in existing programs. Computer-assisted design was reported to be included in a new program in only 4 percent of the schools, with no schools reporting computer-assisted manufacturing being included in new program starts. With start-up costs for new technological programs in the vicinity of several hundred thousand dollars and with minimal state support for new equipment budgets, the capability of vocational education to match industrial technological development with state and local funding sources is non-existent. If vocational education is to be a viable training mode in providing human capital to meet our nation's need for skilled labor, there is no realistic alternative to the generalist tools.

The quest for advantage through high technology and information processing will result in increasing demands for technical skills training. Whereas the initial reaction will be to assign the responsibility to engineers, the shortage of engineers will work to the advantage of community colleges and technical institutes. The burden of proof will be upon these institutions to demonstrate that they do indeed have the capability to provide employment-relevant technical training of equivalent quality to that received in a university setting. Associate degree programs in the sciences and engineering technologies must seek to incorporate the kernel knowledges that will support contemporary technology and provide the graduates with a basic grounding in the theories and practices necessary to support production applications.

Community and technical colleges provide a ready-made network for the assumption of this technical training role. Campuses are located at strategic points designed to maximize coverage of state populations. These postsecondary institutions have a history of community involvement that derives from their founding mandate. Funding from local tax base provides a strong rationale for education to support the community, industry and service base.

Secondary vocational education will play a critical role. This role will increasingly become one of a) providing training in the basic skills as they apply to work and, b) providing the work experience opportunities for the employment of these skills in real job settings. The importance of basic educational skills, as applied in a work setting, cannot be overlooked. It is not simply the ability to compute, to read, to write and to communicate that is at issue, but rather the ability to utilize these skills in a manner and under the settings and conditions found in the work-a-day world. For example, reading for comprehension tested by the ability to recall may do little to develop the skills required in reading to locate specific pieces of information or to follow instructions. Writing themes may be a far cry from filling out work reports, inventory orders and other writing requirements found on the job scene.

Secondary vocational education should not regard the development of these skills as remedial, but rather as a basic function and purpose of secondary vocational education. Since academic education will not and very likely cannot relate education to work, this should become a central responsibility of vocational education. The point being made is that the strands relating education and work are those underlying basic communication and interpersonal skills rather than the more occupationally specific methodological procedures and practices that characterize many secondary programs. The fallacy of this approach is that technological advancements are changing the face of job requirements to such an extent that the schools can never hope to match this change in the classroom. Equipment costs are prohibitive and instructors with the requisite skills and willingness to work at school salary levels are becoming ever more scarce. Schools lack the flexibility because of their organizational structure to tailor their course content to individual employer needs. Continuation of the pursuit of occupational specificity in training without the concurrent capacity to incorporate these changes in curriculum will support the contention that education is becoming increasingly less relevant and the schools not interested in supporting economic growth.

Focus on basic job skills does not mean an abandonment of the employment focus. Employability training should be a central theme of secondary vocational education. By this is meant more than training in interviewing, resume writing and job seeking. The concept of employability should be crossed with the concept of trainability to reflect the employer's concern for people who have the skills to work within an organizational setting, to understand that rights carry with them responsibilities to make a corresponding productive commitment to the organization and its purposes.

Secondary vocational education, to meet the demands of a restructured economy, will have to become increasingly more oriented to education for work rather than education for specific occupations. Obviously, there are differences in the world of work that dictate differential applications of basic skills. This could be handled by adopting a cluster approach for the organization of secondary vocational programs. Since there is ostensibly little difference in the more fundamental knowledges and skills required in retail selling, it makes little sense to differentiate vocational programs according to the type of merchandise sold. What is important is that the students have a grounding in the basic skills that will enable them to perform the fundamental job operations and allow them to function in a variety of retail occupations. Basic skills should be supplemented by a knowledge and understanding of the basic vocabulary and kernel concepts that are necessary to provide an orientation to employment within the cluster. Co-op programs provide an ideal mechanism for providing the students with work experience that serves to give the students an opportunity to sample a selective slice of organizational experience within that cluster.

Secondary and postsecondary institutions should collaborate and seek to provide an articulated career path from the work experience emphasis of the secondary to the more technical postsecondary orientation. This linked pathway provides the student with the means for progressive career development and for building upon knowledges, experiences and interests in a constructive and cumulative fashion. Given the existence of articulation channels, the student has the choice to follow designated upward career mobility pathways or to exit and seek employment. For those who choose to exit, knowledge of basic skills, honed by selective work experience should provide them with a foundation of training needed to enter the job market. These students should, however, have a realistic expectation of the types of jobs they are qualified to fill and the anticipated difficulties in planning employment that exceeds their skills level. Beyond that, the choice is theirs.

Focused Short-Term Training

A major educational implication flows from the increasing reliance on technology to sustain and support economic growth and development. Rapid infusion of technology disrupts established labor-capital relations and causes them to seek new equilibrium. In the process, new skills are created and others become obsolete. Refurbishing human capital to meet the demands imposed by new technology places a particular set of demands upon the training system. First and foremost is that of expediency. Skills must be developed quickly so as not to delay the competitive benefits to accrue from the technological adoption. Training requirements are specific and are derived from the operational constraints imposed by the new technology operating within the established context of organizational policy and procedures.

Vocational education, to serve this need, must have the flexibility to react rapidly and responsively to specific training needs. A significant aspect of this need may well be an assessment of the human skills reauirements induced by technological innovation and the determination of a training plan to satisfy these needs. Since most new jobs are created by small businesses who have few resources to devote to staff support functions, the capability of vocational education to respond rapidly and accurately to their training needs will be an especially critical factor. These small companies, in seeking to maintain a viable competitive position, make frequent changes in their products and processes. To be beneficial to these small organizations, vocational education must be able to change with the same alacrity. Clock hours, classroom schedules and other institutional barriers diminish this capability. What is required is a training extension function with the mobility to offer training on location when and where needed. Such training is generally focused in nature and of short-term duration.

Vocational educators are by profession, educators. This means that their expertise should focus principally on the design, implementation and monitoring of company training programs. Knowledge of the technology and its applications should be provided by company technical personnel. In this sense, vocational educators would be providing a function normally performed by a training department. Since many small firms potentially in need of training have no formally constituted training department, an industrial training role for vocational education would seem apropos.

STATE LEVEL STRATEGIES

State vocational education agencies are in a position to influence vocational education's contribution to productivity improvement and technological innovation through the exercise of informed and creative leadership. Towards this end, the following suggestions are offered. To facilitate organization, suggestions will be grouped according to major agency functions.

Program Planning

Productivity improvement and strengthening technological innovation should be included on the vocational education planning agenda. Existing state level vocational education goals should be reviewed to determine the extent to which these goals support productivity improvement and strengthen technological innovation. If not already formulated, new goals making explicit the state's commitment to these ends should be established.

These goals, to be meaningful and to have the potential to induce change, should be derived from a participatory process. The first step in this process is one of awareness building. Vocational educators must first be aware of the productivity problem and the conditions surrounding the need for technological innovation. Awareness building is a slow and methodical process that must be engineered carefully in order to build a consensual basis to support future efforts.

Awareness can be achieved through a variety of ways. One way is through state program meetings where the topics are introduced and a local dialogue initiated. Another means is to hold a series of workshops devoted solely to the topics of productivity and the impacts of technological change. The benefits of these workshops is that they allow a more sustained period to be devoted to a discussion of the issues and implications surrounding these topics. The results of these workshops should be recorded and used as input into the planning process.

Responsibility for productivity/technology concerns should be assigned to a specific individual within the state agency. This individual functioning as a coordinator would serve as the vehicle for focusing state efforts in this area. Program supervisors should be involved in a dialogue to determine how a concern for these topics can be infused into their program area.

Input from the program supervisors and comments and concerns generated from the field should be translated into goals concerning productivity and technology. These goals should provide the basic direction for a state vocational education agency thrust to involve vocational education in productivity improvement and technology innovation.

Goals pertaining to productivity and technology should be injected into the local planning process. Local agencies and institutions could be requested to assess the local community needs with respect to emerging technology and to describe the ways and means proposed to be used to increase the capacity to respond to these identified needs. To facilitate the local planning effort, the State Vocational Education Agency could provide information descriptive of the technologies most likely to be utilized as a function of the State's economy and could include any available information describing the educational and training implications of these technologies. The information contained in the series of papers entitled "Technologies of the 80s--Their Impact on Vocational Education" (CONSERVA, 1982) could be used as an information source. This information should be supplemented by more state-specific information to the extent that it is available. Sources for this information might include: State Economic Development Agencies, State Departments of Labor or Commerce or other departments dealing with business affairs.

Program Funding

Program funding could be used to stimulate local interest in productivity and high technology. At the postsecondary level, high technology planning grants could be made available to encourage postsecondary institutions to identify the technical knowledges and skills required in designated high technology areas and to determine how these skills might be incorporated into new and/or existing programs. Certain postsecondary institutions may be designated as centers for specific high technology areas and high technology program development concentrated at those centers.

Industry-specific training grants could be provided to stimulate postsecondary institutions to provide training to local employers on an as needed basis. The grant mode could be used to target funds more specifically to industry training associated with high technology applications. An alternative to the project approach is to fund these activities on an FTE basis. While it may provide for more expediency in the funding process, there is a tendency to fund these programs at a lower FTE rate and thereby encourage the serving of this need through regular programs. This frequently defeats the purposes of these programs as it inhibits instructional flexibility to tailor the program to serve unique employer needs.

Special equipment grants could be given to purchase equipment associated with high technology areas. In order to economize, postsecondary applicants should be encouraged to acquire simulators that are designed for teaching purposes. In the area of robotics, teaching robots are available that incorporate all the functions of the larger relatives but are considerably less expensive since they are not built to perform industrial jobs. The same can be said for areas such as computer numeric controlled equipment. In this area it should be possible to simulate the computer control and to learn in a simulated environment, thereby avoiding the expense of acquiring the associated metalworking machinery. The state agency should provide applicants with information as to where they might acquire simulators that could be used in high technology instruction.

At the secondary level, project funding should be made available to encourage the infusion of a productivity emphasis in vocational education course instruction. An awareness of productivity and its importance to the American economy should be clearly understood by every vocational education secondary student. An introduction to a factor theory of productivity and how these factors affect production costs is an important aspect of the understanding of work in America and should be the subject of debate and discussion. Whether these topics should be included in a course on the American enterprise system or infused in the fabric of every vocational education course is a matter for individual discretion. Teaching the basics of productivity is a uniquely vocational education function and is a significant portion of the world of work process.

The definition of employability skills should be expanded to include not only attitudes and values but also the ability to work in an organizational setting. A major contributor to productivity improvement is the capability of workers to participate in an informed and responsible manner in the governance of their work setting. As management offers workers the opportunity to share in the decision making regarding the structure of work, workers in turn must be prepared to accept that responsibility and to act with a consideration of the impact of their decisions on their fellow workers, their company, and society. Thus, vocational education must prepare workers to operate in a more permissive management climate. The price for this new freedom is that workers must share in the responsibility for the outcomes. To behave more responsibly requires that workers have greater organizational skills that will enable them to function in a group participation mode. These skills should include group decision making, problem solving and a better understanding of cost and quality considerations and how they impact upon production. Vocational education can no longer claim that simply by teaching job skills, they have met their productivity responsibilities. If they believe their adage that they are training the whole person, then they cannot afford to ignore the work climate, the extended organizational and interpersonal skills that will be required of the modern worker to participate with management in a new partnership for mutual benefit.

Funds should be made available to support articulated projects between secondary and postsecondary institutions. To promote articulation, built-in incentives should be provided. One such incentive would be for the state to provide a greater share of the funding than is the average. This incentive would serve to demonstrate the state's interest in promoting articulated projects.

Research and Development

Participation in technological innovation should be a prominent subject for State vocational education R & D. Research activities should be devoted to determining those industries and technological innovations that will most likely impact the state economy. Projects should be funded to identify those industries most likely to be affected by technological innovations, the nature of the technological innovations, occupations most likely to be affected and the projected timeframes and incidence of dissemination of these innovations. The technologies identified in the series of papers, "Technologies of the 80s: Their Impact on Vocational Education," (CONSERVA, Inc., op. cit.) would appear to be a useful information guide. However, a similar analysis must be performed that is addressed to the specific needs of states and substate regions.

Curriculum development efforts should be undertaken to ascertain what skills will be required by forthcoming technological innovations and what should be the distribution of these skills between secondary and postsecondary education. If secondary vocational education is to support the development of technical skills by providing a foundation of basic skills and an understanding of the world of work organization, then there need to be identified channels for the development of technological skill requirements. These channels, once identified, will indicate to secondary students those competencies that they will have to master in order to obtain employment and the educational levels at which these competencies can be expected to be learned. Curriculum efforts should be competency based with the caveat that the competencies not be narrowly defined. Instead, competencies should reflect rather more generalized job skill areas which should become progressively more focused as students progress from secondary to postsecondary to on-the-job training. There is no reason except turf protection that precludes linked curricula which provide for an orderly progression from secondary to postsecondary to apprentice or on-the-job training. States can no longer afford to have duplicated, fragmented vocational education delivery systems more concerned with boundary maintenance than with the development of a skilled work force. Proof of their concern will be the extent to which they are able to develop curricula that link different educational systems each with separate governance structures.

Curriculum development efforts should be focused on ways to teach productivity in the vocational education classroom. Productivity curricula should be developed and the appropriate age/grade levels determined. These curricula should address an increasing awareness and understanding of the American economic system, its growth and diversity, the role of costs and competition in a free enterprise system, and most importantly, understanding that nothing comes free. Curriculum efforts should also be addressed towards development of organizational skills aimed at improving worker functioning in such contemporary groupings as quality circles, work teams and other small worker groups that address productivity problems in the workplace.

Of critical importance is the development of curricula to teach computer literacy. Computer literacy does not translate into the simple learning of a program language. Computer literacy, in its broadest connotation, implies a familiarity with the computer as an information processor, a fundamental understanding of the structure of information, its storage and retrieval and a feeling for the basic grammar underlying computer programming languages. Computer literacy curricula should be developed that is oriented to computer literacy and the application of this literacy to real world situations. No vocational education student should be considered competent to enter the workforce without this exposure.

Demonstration projects have a specific role in technological innovation. Specific institutions should be selected as centers for specific high technology areas. By selecting specific institutions, a critical mass can be developed at that organization that will support innovative development. These centers for technological training should be used in a demonstration capacity. As curriculum projects are developed and implemented, vocational education personnel from other institutions should be invited to observe the functioning of these programs. By serving as demonstration sites, these centers can provide visible evidence of on-going efforts to implement high technology training and can serve to increase efficiencies by disseminating their experiences to others.

Professional Development

Vocational education is hindered in its efforts to move into high technology areas by a lack of trained staff. Every effort must be made to ensure that vocational education instructors keep abreast of industrial technology. This does not mean to imply that they should be experts in its application, but rather that they should have a fundamental understanding of the technology, its application, and its educational skills implications. Because high technology is in such a stage of flux with developments occurring so rapidly, it is difficult for educators to comprehend the breadth and scope of the innovations. In order to keep abreast, vocational educators must have exposure to the current high technology. This may be accomplished by a variety of means including: leave to work in a high tech industry, high technology training workshops, trade fair and association attendance, contact with university personnel, attending university courses or self-study. Incentives should be provided to encourage professional development.

Professional development efforts should not be confined to instructional staff. State-level consultants should seek to expand their level of knowledge regarding technological innovations in their area of expertise. Frequent workshops should be conducted that deal with technology and its educational significance. An effort should be made to maintain a collection of materials devoted to new technologies in the vocational education program areas. These materials should include not only recent research and development activities but also current textbooks, monographs, magazine articles and manufacturers' descriptions. State agencies should subscribe to services that provide a continued update as to technological advancements that are currently available. Such a service would be of great advantage to vocational education supervisors by providing them with an overview of advancements in their field.

Technical Assistance

Provision of technical assistance to field personnel would require informed state-level personnel. Technical assistance could take the form of identification of major technologies that could be expected to be adopted given the industrial mix of the state economy. Procedures for locals to use in conducting technological needs assessments in their own area could be developed and used as guidelines by the locals in their technological planning efforts. A data bank pertaining to productivity statistics and associated economic and demographic data could be maintained and made available to local educational agencies and institutions. Information could be organized around specific issues and issue papers written directing local attention to problems of emerging concern. Such problems might be the growing need for retraining due to technological displacement, the impact of the computer revolution or any number of areas selected for focus.

In addition to selected data sources, the state agency could make available productivity and technology-related materials. This information might include systems and procedures used successfully by industry in their productivity efforts, films and other audiovisual materials dealing with productivity, articles, monographs and other printed discussions that would help field personnel to better understand the scope and magnitude of the problem. As some states have already done, state agency personnel could be made available to put on a series of awareness workshops regarding productivity and technology and/or to give lectures and lead discussions for various professional groups. By serving as a fount of information regarding productivity and technological innovations, the State Vocational Education Agency could perform a valuable technical assistance function.

Administration

What better way could there be for state-level administration to become concerned with productivity than to seek to improve the productivity of its own operation. Quality circles could be utilized as a means of seeking to improve the productivity of public sector employees. Engaging in productivity efforts would serve two major purposes. First it would emphasize the importance of productivity considerations to state-level staff and focus their thinking on the impact of management climate on the productivity of the workplace. Through practical experience in employee participation, state-level staff would learn first hand the strengths and limitations of participatory management. This would provide a valuable experience base for expanding upon the role of vocational education in productivity improvement through the worker participation. As a second benefit, productivity efforts at the state level may result in significant organizational and administrative changes as a function of engaging in the participatory process. After all, who knows, if participation works in industry, it may work in education.

Business/Industry Linkages

Both productivity improvement and technological innovation depend upon a high degree of involvement of business and industry. Local education agencies and institutions should be encouraged to make improved use of their program advisory committees as a source of information regarding the changing business and industrial requirements. Advisory committee members should be polled regarding their capital investment plans and should be utilized to the extent possible as 'link-pins' to expand communication with a broader range of business and industries in the community. Surveys should be conducted to determine anticipated capital investments, their impact upon employment, and the anticipated changes in skills requirements. This information will not always be easy to acquire, especially if layoffs are anticipated.

Vocational education institutions should be encouraged to use the theme of productivity improvement as a means of making contact with local employers. One way this theme could be utilized would be to offer a short-term seminar for local employers in productivity improvement efforts. The seminar could be planned to provide a forum for the discussion of productivity problems that local employers are experiencing and a discussion of how the problems may be resolved. As a local community effort, the institutions could arrange for employers to tour other employment establishments and to review their operations and make recommendations for productivity improvements. The fact of combined experience and the opportunity for employers to think through their productivity problems demonstrates the catalytic role that vocational education can perform in stimulating productivity improvement.

As another variant on the productivity theme, local vocational education personnel should attempt to develop short courses in productivity topics. Such topics might include productivity definitions, measurement systems and ways to design, implement and monitor worker productivity efforts. These courses should be offered as adult continuing education courses with time schedules selected to maximize the convenience of attending employers. An effort should be made to solicit employer participation in these programs by emphasizing the bottom line results to the employer.

A variety of productivity-related services could be provided by area vocational schools and postsecondary institutions. These services might include a library of productivity-related information that could be available to local employers. In addition to productivity materials, this library might contain information on technological innovations of concern to local industries. Local community colleges could provide a productivity/technology information reference service that could produce a bibliography of relevant information upon demand. Given the capability of small microcomputers, the development of such a service would be a relatively simple matter given the resources. Resources might be acquired by charging local employers a user service fee. Information could easily be extended beyond bibliographic reference material to include films and other audiovisual materials as well as productivity systems used by other industries. By providing this service, vocational education could demonstrate its interest in employer problems and its ability to make constructive suggestions as to their solutions.

As a further expansion of services, community colleges and area vocational schools could develop the expertise to provide on-site training to employers upon request. This expertise would be a natural outgrowth of the services previously described. As vocational education institutions demonstrated their commitment to employer problems, employers could be expected to request assistance in specific areas.

As vocational educators demonstrated their expertise to deal with industry problems, particularly small businesses, a sense of trust and confidence would develop that would support a relationship on a continuing basis. For those firms without a formal training department, vocational education should be able to function as an independent training deliverer. Vocational education, by virtue of the fact of its public subsidy, should be in a unique position to offer training at an attractive cost to the employer. Contract training, wherein the employer pays a percentage of the cost of training, would provide a source of resources for vocational education and an on-going communication linkage with employers. This communication linkage should serve to make vocational education institutions increasingly responsive to the training needs of employers and should provide a valuable opportunity for placement of program graduates. Given that vocational education earns its respect by providing a needed service, its continuing prosperity is assured.

REFERENCES

"America's Restructured Economy." Business Week, Special Issue, June 1, 1981, pp. 55-100.

"America's Skilled Trades Shortage: A Positive Response." Prepared by the Public Affairs Committee of the Task Force on the Skilled Trades Shortage, Brecksville, Ohio, March 3, 1981.

Ayres, R. U. and Miller, S. "Robotics, CAM, and Industrial Productivity." National Productivity Review, 1,1, Winter 1981-82, pp. 49; 54.

Birch, D. L. Presentation to the Council of Upper Great Lakes Governors, delivered at the Symposium on Small Business, Green Bay, Wisconsin on March 5, 1982.

Cornish, B. M. "The Smart Machines of Tomorrow--Implications for Society." The Futurist, August 1981, p. 6.

Harris, L. and Associates, Inc. and A. Etzioni. Perspectives on Productivity: A Global View. A Sentry Study, Stevens Points, WI: Sentry Insurance Company, 1981.

Hedden, R. A. "Shrinking Workforce Cripples Productivity." Production Engineering, September 1979, pp. 87-88; 93; 95.

Hill, C. T. and J. M. Utterback. Technological Innovation for a Dynamic Society. (Pergamon Policy Studies-50) New York:- Pergamon Press, 1979.

Howard, R. "Brave New Workplace." Working Papers, November/December 1980, pp. 21-31.

Jaffe, J. A., E. H. Oglesby and D.W. Drewes, eds., Technologies of the '80's: Their Impact on Vocational Education. (A collection of seven documents, one focusing on each of vocational education's major instructional areas), Raleigh, NC: CONSERVA, Inc., September 1982.

"The Key to Productivity is People, Not Machines." Highlights of an interview with H. Ross Perot. Government Executive, June 1981.

Lippman, T.W. "Managements Blamed for Output Drop." The Washington Post, January 7, 1982, p. D-10.

Lublin, J. S. "Steel-collar Jobs: As Robot Age Arrives, Labor Seeks Protection Against Loss of Work." The Wall Street Journal, Monday, October 26, 1981, pp. 1; 21.

"Old Machines Contribute to Declining U.S. Productivity." Productivity, January 1980, p. 7.

O'Toole, J. Making America Work: Productivity and Responsibility. New York: Continuum Publishing Company, 1981.

Prestbo, J. A. "New Industrial Revolution is Near, Economist Says, but U.S. May Lag." The Wall Street Journal, June 4, 1981, Section 2, p. 29.

"Revitalization of Plastics Manufacturing: Blueprint for Survival." Plastics Technology, September 1981, pp. 66-97.

"RIA News." Robotics Today, Spring 1980, p. 7.

Riche, R. W. "Impact of Technological Change." Presented to OECD's Second Special Session on Information Technology, Productivity, Working Conditions and Employment. Paris, France, October 19-21, 1981.

Thor, C. in "Solving the Mystery of Productivity Measurement," Industry Week, January 26, 1981, p. 62.

Thurow, L. C. "The Productivity Problem." Technology Review, November/December 1980, pp. 40; 42-51.

U.S. Chamber of Commerce. Statement of the Chamber of Commerce of the United States on Productivity, presented to the Subcommittee on the Senate Committee on Labor and Human Relations by Dr. Ronald D. Utt on April 2, 1982.

U.S. Congress. Joint Economic Committee. "Japanese Productivity: Lessons for America." Hearing before the Subcommittee on International Trade, Finance, and Security Economics, November 4, 1981.

U.S. Congress. Joint Economic Committee. "Shortages in Skilled Labor." Hearing before the Subcommittee on Economic Goals and Intergovernmental Policy, November 3, 1981. Washington: GPO 1982.

U.S. House of Representatives. Committee on Armed Services. "The Ailing Defense Industrial Base: Unready for Crisis." Report of the Defense Industrial Base Panel, December 13, 1981.

U.S. House of Representatives. Committee on Banking Finance and Urban Affairs. "The Federal Role in Private Sector Productivity." Hearing before the Subcommittee on Economic Stabilization. Testimony by Howard J. Samuels, January 27, 1982, p. 63.

U.S. Senate. Committee on the Budget, "Industrial Growth and Productivity," Hearings before the Subcommittee on Industrial Growth and Productivity, December 3 and 5, 1980; January 26, 27, and 28, 1981. Washington: GPO, 1981.

U.S. Senate. Labor and Human Resources Committee, Subcommittee on Employment and Productivity. "Recent Productivity Trends in the U.S. and Japan." Testimony by J. R. Norsworthy, April 2, 1982.

"Vocational Education Equipment Needs." Stout, WI: University of Wisconsin, November 1981.

Wakefield, B. D. "America is Running Out of Manufacturing People." Production, April 1980, pp. 77-85.

Waters, C. R. "There's a Robot in Your Future." Inc., June 1982, p. 68.