Chapter 6

Education, Training, and Retraining Issues

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Chapter 6

Education, Training, and Retraining Issues

Summary of Major Findings

Programmable automation (PA) is one of a number of forces currently reshaping the roles for and values assigned to education, training, retraining, and related services such as career guidance and job counseling.

Strong basic skills in math, science, and reading serve as the foundation for instruction for programmable automation. Instruction for semiskilled and skilled production line workers in automated facilities must emphasize conceptual and problem-solving skills as much as motor skills. Instruction for technician-level occupations common to automated facilities must focus on the development of multiple skills (broader training) and on an understanding of how programmable equipment interfaces with other components of the manufacturing process. Instruction for engineers who work in automated plants must emphasize a broader based knowledge of engineering operations and stronger management skills.

A key ingredient in successful PA instructional programs is close cooperation between industry, educators, labor, and government in such areas as skills assessment, curriculum design, equipment acquisition, location of qualified instructors, and job placement. However, in most cases, this degree of interjector cooperation is left to chance and often does not occur.

The present capacities of the U.S. instructional system, characterized by inadequate facilities, shortages of equipment, and an inadequate supply of instructors, may constrain the establishment of adequate skills-development strategies for programmable automation. This is as true for most industry-based instructional programs as it is for programs offered by more traditional public and private educational institutions. There are no indications that these barriers to instruction will disappear over time, without specific, corrective actions.

Population groups served by different types of instructional programs, as well as the numbers of individuals taking advantage of instructional services, are changing. However, individuals who are most likely to be affected by technological and economic change-those with lower incomes and lower levels of educational attainment-seem to be the least inclined to enroll in instructional programs in order to develop new, more marketable skills.

Special approaches will be required to ensure that retraining programs and job counseling/outplacement assistance geared to the unique needs of displaced workers are developed and implemented. In the past, retraining for displaced workers has often been a "force fit, " and participation rates have been low.

Introduction

The use of programmable automation in manufacturing is one of a number of forces reshaping education, training, retraining, and educational guidance/job-counseling services in the United States. Among the other forces creating increased demand for instruction are: 1) technological change occurring in office and service sector environments, 2) broad-based economic change induced by U.S. participation in international markets and shifts in demand for goods and services, 3) demographic change, and 4) increased interest in education and training for personal and professional development. These forces may, in the long run, facilitate or impede the establishment of well-founded instruction for programmable automation, depending on the aggregate demand they generate for skills development and the instructional resources required to address this demand.

Accordingly, the goals of this chapter are threefold: to describe how the roles for and values assigned to instruction are changing as a result of economic, technological, and demographic change and the heightened sense of the "unknown" created by this change; to examine specific instructional responses to skills requirements for programmable automation at this early stage of adoption of the technologies; and to discuss how present capacities of the U.S. instructional system may affect skills development strategies for programmable automation in the long term.

A wide variety of sources, including education and training literature, personal interviews, and site visits to manufacturing facilities and instructional centers, were used in developing this account of a changing national instructional system and in depicting how programmable automation is being addressed by that system. Fourteen in-depth case studies created for OTA describe selected, currently available education, training, and retraining geared to PA. They served as a particularly rich source of information in the development of this section of the report.

The Changing Context for Education, Training, and Retraining

In 1983, a number of studies were released which reflected growing national awareness of the importance of education, training, and retraining to international economic competitiveness, as well as concern over the current state of elementary, secondary, and postsecondary instruction in the United States. Among the studies that have received the most attention are those of the National Commission on Excellence in Education *(A Nation at Risk: the Imperative for Educational Reform)*;[1] the Education Commission of the States *(Action for Excellence: A Comprehensive Plan to Improve Our Nation Schools)*;[2] the Business-Higher Education Forum *(America Competitive Challenge: The Need for a National Response)*;[3] the Twentieth Century Fund Task Force on Federal Elementary and Secondary Education Policy *(Making the Grade)*;[4] and the Carnegie Foundation for the Advancement of Teaching *(High School)*.[5] In addition to emphasizing the obstacles represented by shortages of equipment and qualified instructors-particularly in science and math—these reports point to the low student participation rates in science and math beyond the 10th grade, the high levels of functional illiteracy within the general population, and the implications these conditions have for continued U.S. economic growth and participation in a world economy that is increasingly technology-driven. The reports of the National Commission on Excellence in Education, the Education Commission of the States, and the Business-Higher Education Forum all recommend a reassessment of the U.S. educational system and curricula in light of changing world conditions, including the growing use of advanced technologies in the workplace.

Given current levels of concern over the U.S. competitive position and the links between continued development of the human resource and sustained economic growth, it is difficult

[1]National Commission on Excellence in Education, *A Nation at Risk: The Imperative for Educational Reform* (Washington, D. C.: U.S. Government Printing Office, April 1983).

[2]Education Commission of the States, *Action for Excellence: A Comprehensive Plan to Improve Our Nation Schools* (Denver, COLO.: Education Commission of the States, June 1983).

[3]Business-Higher Education Forum, *America Competitive Challenge: The Need for a National Response* (Washington, D. C.: Business-Higher Education Forum, April 1983).

[4]*Making the Grade: Report of the Twentieth Century Fund Task Force on Federal Elementary and Secondary Education Policy* (New York: Twentieth Century Fund, Inc., 1983).

[5]Ernest L. Boyer, *High School* (Princeton, N. J.: The Carnegie Foundation for the Advancement of Teaching, 1983).

to understand why the relationship between education and training and economic expansion has recently become a focus of national attention—especially since the effects of education on the labor force have been the subject of economic analysis for many years. Part of the answer may lie in traditional economic measures used to quantify returns on educational investment. These measures examine the relationship between different levels of educational attainment and lifetime wages, without taking into account all other influences on lifetime wages:

> In the interest of precision, economic analysis has narrowed human contribution to its most measurable aspects such as wages and hours worked. So long as wages and other measurable evidence of human participation in the economy were on the rise, everything was fine, Interested parties, especially educators, were satisfied to know that rates of return to human investment were high and increasing as the economy boomed and wages and leisure increased. With economic decline and unprecedented demographic change, however, wage returns on human investment have headed downward. Those who swallowed the simplistic "human capital" assumption that wage returns capture the overall economic return to human resource development in good times are, unfortunately, hooked when the economy turns sour and wages decline. What we need is a more sophisticated means for measuring human quality and its impact on the economy. Unless we can find such a method, we will continue to miss the woods for the trees in assessing the relative importance of human factors in production.[6]

Regardless of how the human resource has been viewed as a factor in production, or how well its effects on the economy have been measured, industry, labor, and government leaders all recognize that a highly developed human resource pool is critical to maintaining U.S. competitiveness. Individuals will therefore place pressure on the U.S. instructional system for programs that develop human skills essential to continued work force participation.

The automated manufacturing environment represents but one of a number of work settings out of which new skill requirements will emerge in the years ahead. Therefore, it is important not to overemphasize PA-related skills to the neglect of other types of general and occupation-specific skills. The development of strong basic skills in math, science, and communication remains an important educational priority for the work force as a whole. * Given the increased use of computers in many aspects of American life, the demand for computer literacy programs is on the rise. In addition, there is a need to better prepare individuals for greater exposure to new technologies in their day-to-day lives, whether or not they choose to be work force participants. This involves the development of a basic understanding of scientific principles and processes, as well as of the relationships that exist within the physical world.[7] A recent report of the National Science Foundation's Public Understanding of Science Program made reference to:

> . . . the increasing gap between the relatively small technological elite and the far larger public that is both poorly equipped to understand new developments, and is effectively precluded from significant careers related to science, engineering and high technology. Thus, to maintain a vigorous and widely representative pool of potential talent for the technological professions; to assure a base of awareness and understanding among decision makers of industry, government, and the press; to encourage the interest and familiarity that are needed to recognize and address the personal and public decisions related to technology; and to meet the Jeffersonian ideal of an informed electorate, . . . an interest and background of experience with the principles and activities of science is critical.[8]

[6]A. Carnevale, *Human Capital: A High Yield Corporate Investment* (Washington, D. C.: American Society for Training and Development, 1983), pp 13-14.

*Other priorities include increased emphasis on foreign languages from elementary school onward and a renewed emphasis on humanities, particularly in interdisciplinary programs, such as "technology and society.

[7]E. Leonard Brown, "Educational Change: Educating for a Transitional Era, " *Futurics*, vol. *7, No.* 3, *1983*, pp. 11-14.

[8]*Summary of Grants and Activities: Public Understanding of Science Program* (Washington, D. C.: National Science Foundation, March 1982), p. 4.

Effects of Programmable Automation and Other Technologies

OTA's analysis of employment effects of programmable automation indicates that computer-based manufacturing technologies will bring about substantial changes in manufacturing skill requirements over time. However, several variables complicate the process of quantifying long-term employment impacts. The most important of these variables are: 1) the rate at which programmable automation is adopted; 2) the flexibility afforded by PA to combine people and equipment in production in different ways; and 3) changing economic conditions affecting product demand, frequency of innovation, intensity of competition and, in turn, labor demand within automated manufacturing environments. *

Even at present low levels of utilization, programmable automation is creating new demands for education, training, and retraining services. In the future, with more widespread use of advanced manufacturing technologies, there will be considerable demands made on the U.S. instructional system for manufacturing-related skills development and for rapid responses to what may be frequent changes in skill requirements. For example, in a recent survey of members of the American Society for Training and Development's Technical and Skills Training Division, 93 percent of the respondents indicated that, based on technological change within their companies: 1) workers in their firms would require "significant changes in skills" on an ongoing basis, and 2) skill changes would typically be required within a relatively short time frame-possibly less than 1 year.[9] Programmable automation will also stimulate renewed demands for the development of strong, basic skills in reading, math, and science that serve as the foundation for PA-related instruction. While some things are known about the effects of PA on skills requirements, other things remain, at least for the time being, unknown—since they will be the outgrowths of future modes of adoption and methods of application.

Adventurous Hosts: 3-2-1 CONTACT'S young hosts Kathy (Kelly Pino), Miguel (Frank Gomez), and Robin (Judy Leak) traveled over 30,000 miles to 80 different locations around the country in search of adventures that bring excitement of science alive for young audiences. This Public Television System series is one of a number of projects funded in part by the National Science Foundation's "Science for Public Understanding Program. " 3-2-1 CONTACT is now the second most popular program on public television. For more information on this NSF Program, see p. 221

The challenge for educators and trainers will be to design and deliver instruction that develops skills with which individuals can better deal with the unknown—i.e., with future

*For a more detailed discussion of impacts on employment and effects on working environment, see chs. 4 and 5.

[9]*Survey of Technical and Skills Training Division,* American Society for Training and Development, 1983.

changes in skill requirements brought on by possible increased use of PA and other factors. Instruction designed to accomplish these ends involves the development of: 1) strong basic skills in reading, math, and science; 2) analytic and problem-solving skills, which enhance an individual's ability to operate effectively in new or modified work environments; 3) abroad occupational skills base which in turn broadens individual career choices and serves as a foundation for the development of additional skills; 4) specific PA-related skills; and 5) a recognition of the need for lifelong instruction to facilitate continued participation in and advancement within the work force. This new, future-oriented approach to education and training allows skill levels to advance at a rate more in keeping with the rate of technological change and stresses the need for flexibility to handle frequent job changes within the same sector or from one sector to another. However, its central focus is on more extensive development of individual potential. It can help preserve or enhance mobility, reducing the chance that workers are locked into, or out of, certain types of work as technologies and the economy undergo change.

This approach to instruction represents a blending of guiding principles from two traditional but disparate schools of thought on the ultimate goal of instruction: "education for work" (focus: occupational preparation) and "education for life" (focus: education for individual development). It also softens the sharp distinctions educators and others have drawn over the years between vocational/technical education and professional education, for it stresses the importance of analytic and problem-solving skills and of broad-based occupational preparation in both kinds of instructional experiences. *

Roles for Instruction in a Changing Society

The combined effects of technological and economic change are now observable in many areas of U.S. society. But technological and economic change are also having pronounced effects on the expectations individuals and employers have for instruction as a tool for personal and professional growth. These expectations take the form of increased demands for specific kinds of instructional programs and services. Accelerated growth in new course offerings, heightened interest among educators and trainers in curriculum development, and new skill requirements or skill shortages expressed by industry are all evidence of these increased demands. Some of the new instructional demands emerge from changing skills requirements in particular working environments. Other instructional demands reflect the impact that technological and economic change is having on society as a whole, and as such cannot be attributed simply to factors present within the workplace. Regardless of the circumstances that result in new education, training, and retraining requirements, the institutions, organizations, and agencies that make up the instructional delivery system in the United States are called on to develop programs and services that are responsive to both individual and employer demands and to supply these programs and services on an as-needed basis. Given current and anticipated rates of economic and technological change, plus the resources presently available to instructional providers for use in addressing demand, individual and employer expectations of the instructional system are not realistic and the full set of demands cannot be met. An abstract discussion of representative individual and employer expectations for instruction, as well as of conditions currently

*The sharp, post-World War II increase in the amounts of corporate, in-house technical and skills training activities has had an influence on the nature and scope of some types of vocational instruction. Instructor and equipment costs associated with technical and skills training for employees, as well as narrowly defined production line jobs, have led to the development of in-house training that is often very narrowly focused and designed to develop only those skills required for discrete clusters of skills. While this approach to skills instruction has worked well for industry in many instances, it has influenced vocational education as a whole by leading to a reemphasis on analytic and problem-solving skills development and a *movement* toward highly specialized instruction. For a *discussion* of how high technology is affecting both the process, content of, and planning strategy for vocational and technical education, see Warren H. Groff, "Impacts of the High Technologies on Vocational and Technical Education, *ANNALS, AAPSS, No. 470,* November 1983, pp. 81-94.

faced by instructional providers, will establish themes that will be examined in greater detail later in this chapter.

Individual Expectations

OTA found that individuals are concerned about how economic and technological change will affect them directly-about the potential for more frequent job or career changes over a lifetime, and about the changes in skills requirements that seem likely to occur within and across established occupations. * Given the recent, extensive media coverage of factory and office automation, individuals now in the work force and those preparing to enter it are particularly sensitive to the potential for technologically induced skills changes. An operator of a flexible manufacturing system, interviewed in the course of an onsite investigation of working conditions in an automated plant of an agricultural implements manufacturer, put it this way: "If you're looking at 15 years or so before retirement, you'll be sweeping floors. "

Regardless of their age or economic status, individuals who make the connection between continued skills enhancement and continued employment want access to instruction that makes the most of their previous training, their core skills, and that corrects basic skills deficiencies that may be interfering with the development of additional skills and proficiencies. These individuals-young people preparing for careers, or adults now employed or recently displaced-also need access to reliable information on skills and occupations in demand, plus assistance in determining what types of instruction will adequately prepare them to compete for available jobs and maintain employment. They also seem less willing than in the past to assume that educators, trainers, and career counselors know what is best for them.

*T& discussion of individual expectations is based on analysis of education and training literature, numerous discussions with employees in the course of site visits to industrial facilities, and conversations with students enrolled in a variety of education and training programs.

Employer Expectations

OTA found that many employers, aware that economic and technological change will affect their operations and their competitive position, are placing increased emphasis on efficiency and productivity. While employers can influence how advanced automation affects workplaces,* they are concerned about how the use of advanced automation may change skill requirements and how these new skills will be developed in current and future personnel. This concern derives, in part, from documented problems of basic skills deficiencies in the current work force and in the U.S. population as a whole.** Employers often hold different views from those of educators on the goals of instruction that occurs prior to employment. The Center for Public Resources polled representatives of industry, labor, and the educational community on how well local school systems prepare individuals for work, as well as on specific competencies based on basic math, science, and communications skills. Survey results revealed a great disparity between industry, labor, and educator views of what constitutes "work-readiness" and what types of baseline competencies employers have a right to expect of employees. The industry/labor respondents had much higher expectations in the area of practical, basic competencies than did the educators.[10]

Regardless of economic sector or geographic location, it is clear from statements employers have made in various public forums, including congressional hearings, that many want an instructional system that produces individuals

*For a detailed discussion of PA-related working environment issues, see ch. 4: "The Effects of Programmable Automation on the Work Environment. "

**The concern for basic skills deficiencies in the general population was first brought to light in 1975, with the release of *Adult Performance Level Study*, the final report for a 4-year study conducted by the University of Texas for the U.S. Office of Education. The report indicated that nearly 20 percent of the adult population of the United States was functionally illiterate and, because of basic skills deficiencies, unable to perform common daily functions such as writing checks, shopping for food, or ordering a meal in a restaurant.

[10]*Basic Skills in the U.S. Work Force: The Contrasting Perceptions of Business, Labor, and Public Education* (New York: Center for Public Resources, November 1982).

who have a strong foundation of reading, math, science, and communications skills; who possess core occupational or professional skills; and who have acquired analytic and problem-solving abilities that will enable them to better adapt to workplace change. In general, employer and individual demands are quite similar, with the exception of the emphasis employers place on *analysis* and problem-solving abilities.

Instructional Providers

At the same time individuals and employers are demanding more from education, training, and retraining programs and related services, the U.S. instructional system is facing unprecedented obstacles—including shortages of instructors in science, math, and technical fields such as engineering; facilities with limited capacities relative to demand; and outdated equipment, This is true for nearly all of the entities that are engaged in the design and delivery of technical instruction, including industry and labor. Educators in publicly supported elementary, secondary, and postsecondary institutions feel constrained by reduced Federal assistance and lower State and local revenues being channeled into instructional programs. Industry-based human resource development personnel, especially those who operate within older industries such as auto, steel, and rubber, are being forced to reevaluate their approaches and programs. They are facing decisions of whether to expand in-house course and program offerings in the face of low profit margins, reduced capital investments, and increased foreign competition—conditions that usually precede a reduction in corporate-sponsored instructional programs-or to attempt to identify other sources of instruction for their personnel.

Labor unions, while successful in negotiating some agreements that call for the establishment of joint union-management training funds for workers on the job and for those who have been laid off, now only represent about 20 percent of the U.S. work force. * Even in industries within which the majority of workers are unionized, unions are operating under conditions more conducive to concessions than to new demands. In addition, for unions and for industry, there is a basic uncertainty about how current instructional programs should be revised or expanded to reflect the increased use of advanced technologies and changing skill requirements, given the ongoing nature of technological change.

Categories of Instruction

In discussing how technological and economic change are affecting instruction, it is important to examine the types of instructional experiences available to individuals.

OTA found that most instructional services fall into one of four categories:

1. Education–initial preparation for work and for life;
2. Training-instruction received upon entry to the work site that bridges the gap, if any, between skills developed through formal education and skills required to function effectively in the workplace;
3. Retraining—all other forms of work-related instruction, including professional development and skills upgrading; and
4. Continuing Education–instruction that is not necessarily directly work- or career-related, but often geared to personal development.

*Such funds require contributions from employers and individuals. For example, the Los Angeles Electrical Training Trust was established in 1964 to support education and training programs for apprentices and journeymen covered under the collective bargaining agreement between the International Brotherhood of Electrical Workers' Local 11 (IBEW) and the Los Angeles Chapter of the National Electrical Contractors' Association. Under the terms of the agreement, Local 11 members contribute to the Trust 5¢ for every hour worked, while their employers contribute 15$ for every employee hour worked. (For more information, see the IBEW case study included in app. A to this report.)

Clearly this range of services, or experiences, constitutes in its fullest form a lifelong program of education. While lifelong education has been talked about in educational circles for a number of years, the combined influences of technological and economic change are making the need for lifelong learning a reality for the current and future work force, regardless of the skill level considered. Individuals are coming to realize that, regardless of their level of educational attainment prior to joining the work force, there are no guarantees of lifetime employment.[11] Workplace change can trigger frequent modifications in job functions, or necessitate job changes or career changes that will require the development of new or enhanced skills. Many individuals may find it necessary to undergo education, training, and retraining several times during their lifetimes. Some of these individuals may get tuition assistance and permission to pursue coursework during working hours from their employers; others may have to draw on their own time and resources. Others may qualify for participation in federally funded training programs or for Federal student loans. Accelerated change in workplace conditions will also increase the emphasis on quality of instruction (e.g., curriculum content, qualified instructors, adequate equipment and facilities) and related services, such as educational and job counseling. It will also generate greater pressure for rapid response to frequent changes in instructional requirements.

[11] Samuel Brodbelt, "Education as Growth: Life-long Learning," *The Clearing House*, vol. 57, October 1983, pp. 72-75.

Current Trends in Instruction

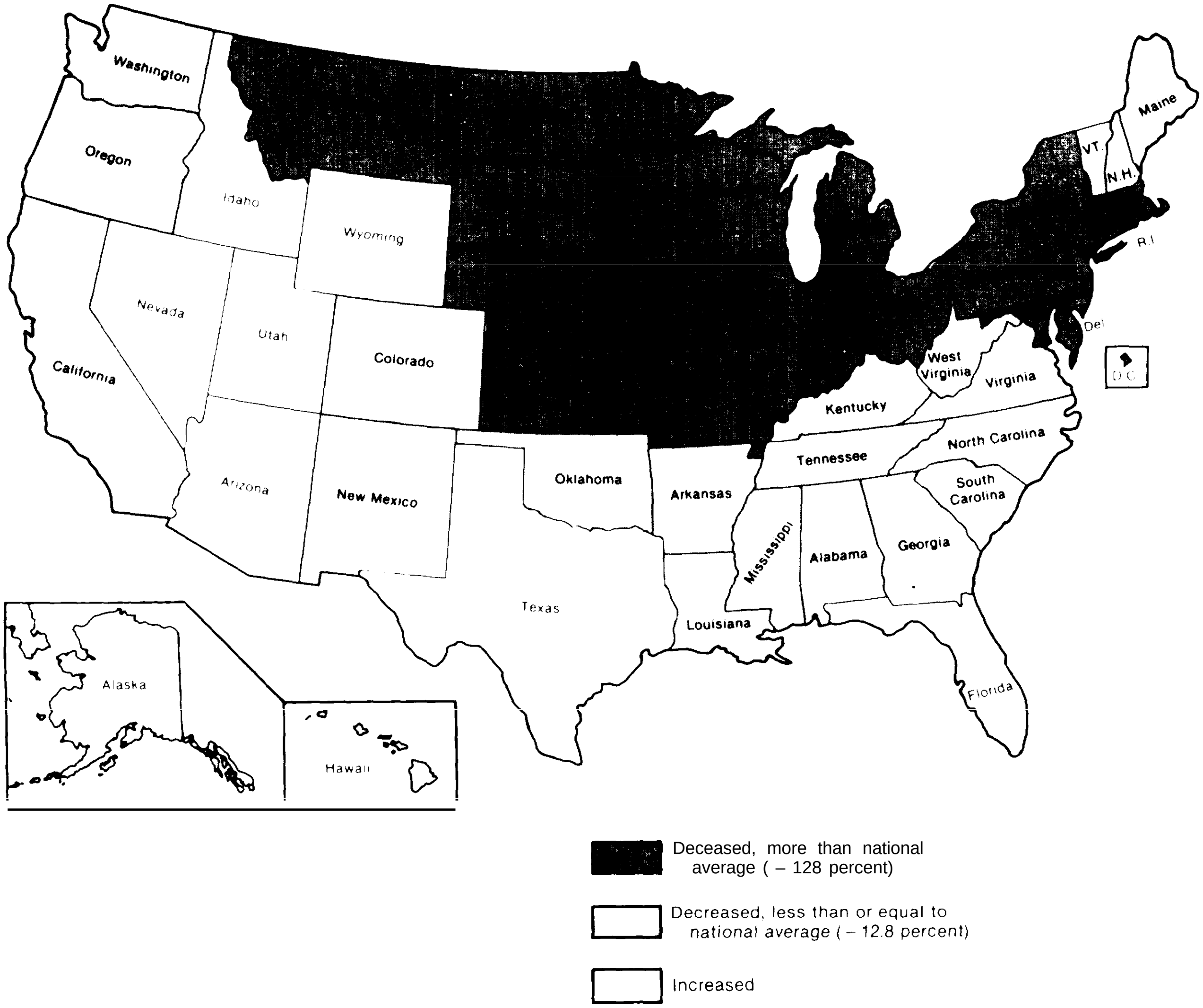
As stated earlier in this chapter, programmable automation is but one of many forces leading to the development of new instructional priorities. It is important to examine what is known about current enrollment patterns and then to focus on new areas of emphasis for the U.S. instructional system as a whole. These conditions establish the context for a discussion of PA-related instruction and an evaluation of the capacities of the education and training system.

Changes in Enrollment

Patterns of participation in education, training, and retraining programs have changed over the past few years. Population groups served by different types of instructional programs are changing. Adults aged 17 years and older with specific personal or occupational goals are participating in education, training, and retraining programs in record numbers. This is in sharp contrast to earlier periods, when the heaviest levels of participation in instruction were found among children and adolescents. These earlier participation rates and patterns reflected the predominant view of the function served by instructional programs–formal education preceded employment and usually ended when an individual entered the work force.

According to the National Center for Education Statistics (NCES), elementary and secondary school enrollments declined by 13 percent between 1971 and 1981. In roughly the same period, enrollments in higher education (2- and 4-year institutions) continued to grow (see fig. 18). Full-time postsecondary students and all those enrolled in 4-year colleges and universities represented only 58.3 percent of total enrollment by 1982. This is attributed to the expansion of public 2-year colleges during this period whose programs were often characterized by open admissions policies, flexible class schedules, and perhaps a greater interest in the part-time, working student. During the period 1970-81, there was evidence of a shift in enrollment from 4-year schools to 2-year institutions, with enrollments in 4-year schools dropping from 74 percent to 62 per-

Figure 18.—Percent Change in Public Elementary/Secondary School Enrollment Between 1971 and 1981, by State



SOURCE National Center for Education Statistics 1982

cent (see table 53 and fig. 19). During the same period, female participation in higher education grew steadily, while male enrollment remained fairly stable. Minority enrollment reached 16.5 percent by the fall of 1980: 9.4 percent of postsecondary students were black and 4.0 percent Hispanic.[12] These data suggest that postsecondary institutions are now serving a much broader audience and, perhaps, a wider variety of instructional needs. Shift in

[12] *The Condition of Education, 1983 Edition* (Washington, D. C.: National Center for Education Statistics). During 1981-82, there were 3,253 institutions of higher education operating in the United States. Of this number, about one third, or approximately 1,2oO, were 2-year colleges. Institutions that specialized in 4-year, baccalaureate-level programs and that did not demonstrate significant involvement in post-baccalaureate education numbered 730. While the vast majority of 2-year colleges were public institutions (933), only 607 4-year colleges, were privately controlled (see table 53 and fig. 19). There were 167 institutions that offered doctoral programs, and another 408 institutions that offered post-baccalaureate programs other than doctoral programs. Some 545 institutions were classified as "specialized" by NCES, in that they placed emphasis on a particular program area, such as engineering. The majority of specialized institutions were privately controlled and offered baccalaureate programs, post-baccalaureate programs, or both. *In* the "new institution" category, 2-year schools *have* dominated since the 1960's.

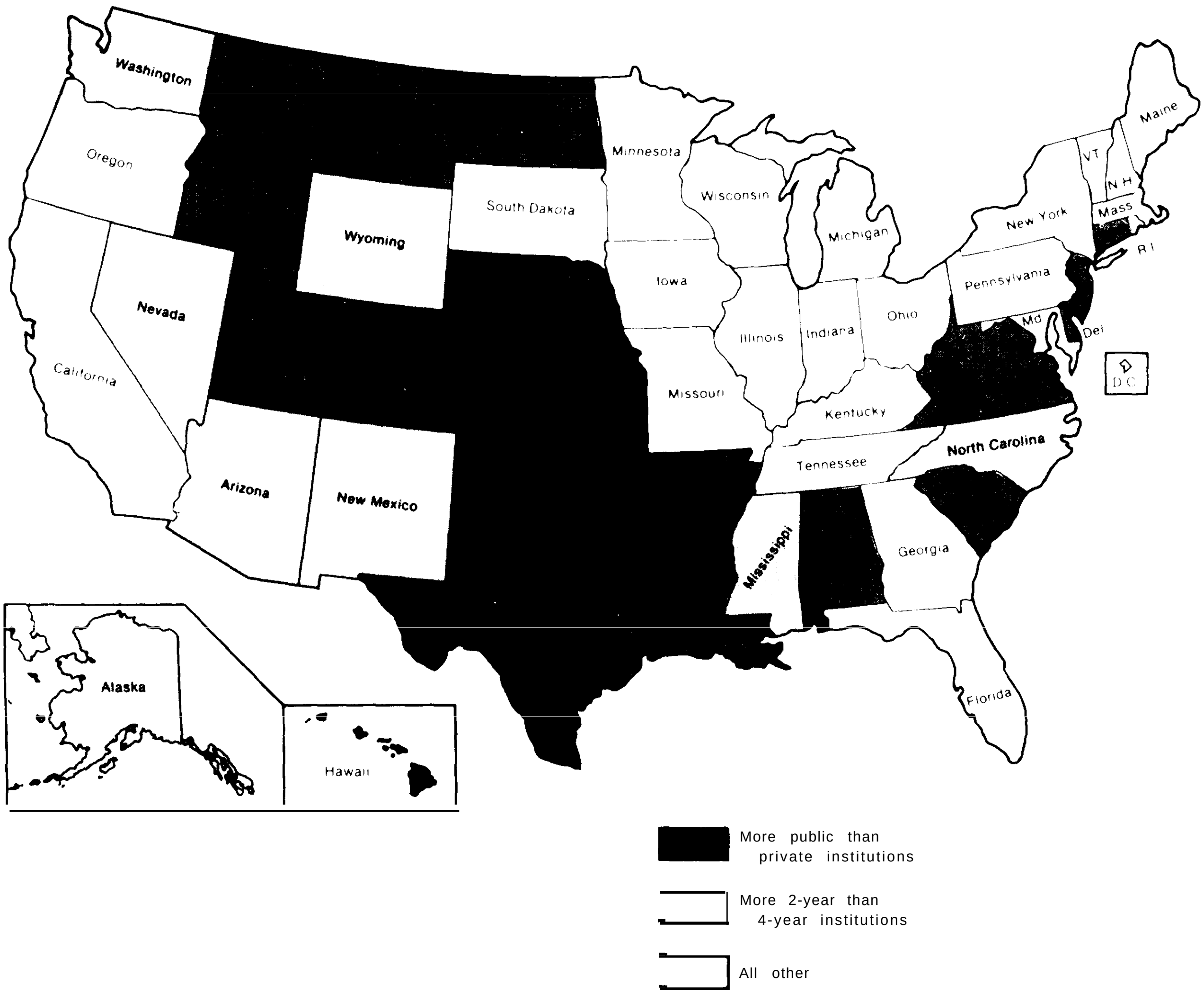
Table 53.-Number of Institutions of Higher Education and Branches by Level, Control, and State: Academic Year 1981-82

State	Total	All Institutions		4-Year Institutions		2-Year Institutions	
		Public	Private	Public	Private	Public	Private
50 States and D C	3,253	1,498	1,755	558	1,420	940	335
Alabama	59	37	22	16	15	21	7
Alaska		12	3	3	3	9	0
Arizona	28	19	9	3	8	16	1
Arkansas	35	19	16	10	10	9	6
California	272	136	136	30	123	106	13
Colorado	45	27	18	18	15	14	3
Connecticut	47	24	23	7	19	17	4
Delaware	8	5	3	2	3	3	0
District of Columbia	19		18		18	0	0
Florida	81	37	44	9	35	28	9
Georgia	78	34	44	18	29	16	15
Hawaii	12	9	3	3	3	6	0
Idaho	9			4		2	1
Ilinois	158	63	95	13	83	50	12
Indiana	74	28	46	13	37	15	9
Iowa	60	21	39			18	5
Kansas	52	29	23	8	20	21	3
Kentucky	57	21	36	8	22	13	14
Louisana	32	20	12	14	11	6	1
Maine	29	12	17	7	13	5	4
Maryland	56	32	24	13		19	3
Massachusetts	118	32	86	15	65	17	21
Michigan	91	44	47	15	41	29	6
Minnesota	70	30	40	10	32	20	8
Mississippi	41	25	16	9	10	16	6
Missouri	89	28	61	13	54	15	
Montana	16	9	7	6	4	3	3
Nebraska	31	16	15	7	13	9	2
Nevada	7	6	1	2	1	4	0
New Hampshire	26	11	15	3	11	8	4
New Jersey	61	31	30	14	26	17	4
New Mexico	19	16	3	6	3	10	0
New York	294	86	208	40	168	46	40
North Carolina	127	74	53	16	34	58	19
North Dakota	17	11	6	6	4	5	2
Ohio	136	59	77	18	62	41	15
Oklahoma	44	29	15	14	11	15	4
Oregon	45	21	24		21	13	3
Pennsylvania	202	61	141	24	108	37	33
Rhode Island	13	3	10	2	9	1	1
South Carolina	60	33	27	12	19	21	8
South Dakota	20	8	12	7	9	1	3
Tennessee	79		55		40		15
Texas	156	98	58	39	52	59	6
Utah	14	9	5	4	3	5	2
Vermont	21	6	15	4	14	2	1
Virginia	69	39	30	15	28	24	2
Washington	50	33	17	6	16	27	1
West Virginia	28		12	12	8	4	4
Wisconsin	64	30	34	13	30	17	4
Wyoming	9	8	1	1	0	7	1
U S Service Schools	10	10	0	9	0	1	0

NOTE: Branch campuses are counted separately

SOURCE: National Center for Education Statistics, 1982

Figure 19.— Level and Control of Institutions of Higher Education, by State

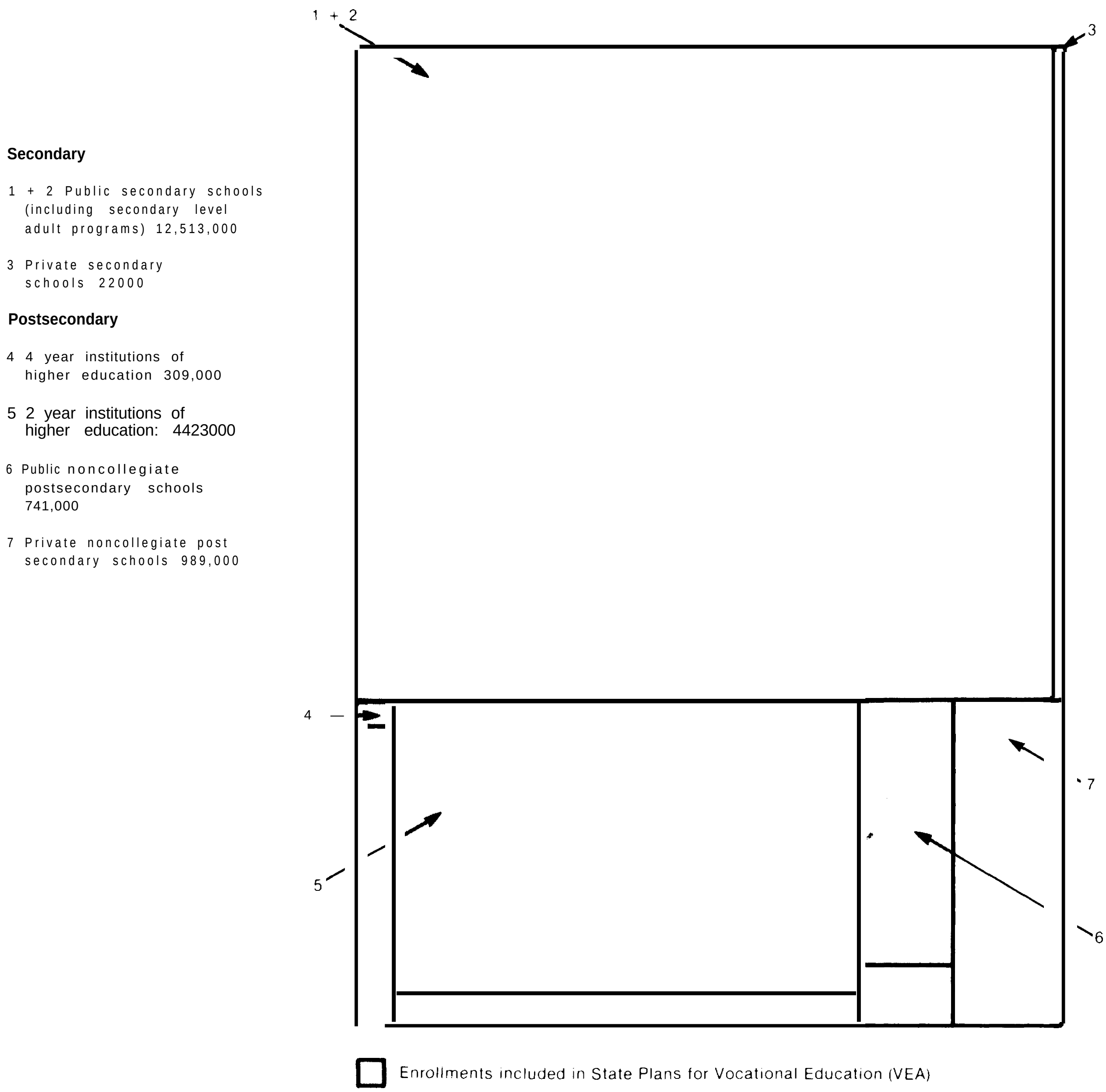


SOURCE National Center for Education Statistics 1982

enrollment from 4- to 2-year programs may refleet the overall growth in demand for technicians (see ch. 4 of this report), since formal educational preparation for technician careers is typically a 2-year associate degree program.

Enrollment in vocational education reached 16.9 million during 1980-81. Among secondary institutions offering vocational education programs, there were 10.5 million enrollments, while postsecondary institutions that were regionally accredited, State approved or classified as "other postsecondary" by the Vocational Education Data System, accounted for a total of 6.4 million enrollments. The most recent information on the types of institutions offering vocational education programs is for 1978-79. Among secondary institutions offering vocational programs, public secondary schools, area vocational centers, and secondary-level adult programs accounted for the largest share of the 19 million enrollments for that period. By contrast, there was much less diversity in postsecondary institutions with significant enrollment levels, with 2-year institutions accounting for 68 percent of all enrollments (see fig. 20). Male and female participation rates in secondary-level vocational education programs varied according to enrollment areas, with females outnumbering males in programs for office occupations and males predominating in trade and industrial programs. Within high schools, there were higher proportions of blacks, Hispanics, and other

Figure 20.—Estimated Enrollments in Vocational Education, 1978-79



SOURCE National Center for Education Statistics minorities enrolled in vocational education programs than in precollege and other types of programs.[13]

The number of adults participating in part-time education programs (usually defined as a course load of 9 credit hours or less), both degree-credit and nonacademic, has risen over the last decade and is expected to continue to rise into the 1990's. According to the results of the 1981 Adult Education Participation Survey, at the close of the year ending May 1981, over 21 million persons age 17 or older were enrolled in adult education programs, representing an increase of over 3 million since 1978, or 17 percent. As was the case in earlier surveys of adult education, the participation rates of whites were markedly higher than those of various other racial/ethnic groups. Whites represented 88 percent of all those engaged in adult education activities. ” Individual level of prior education attainment continued to be one of the strongest factors influencing participation in adult education.* Income level was another key factor.**

Work-Related Instruction

By 1981, approximately 83 percent of those indicating participation in adult education were in the work force—some 17 million people. Of these, 70 percent held white-collar positions, including professional and technical jobs. The 21 million individuals participating in adult education activities in 1981 had over 37,000 courses from which to choose. Close to half of the courses they took were within the fields of business (23 percent), health (14 percent) and engineering (10 percent), and approximately 60 percent participated for job-related reasons. For 42 percent of the men and 26 percent of the women, employers provided some or all of the tuition. Expenditures for adult education in 1981 totaled $2.2 billion; the average expenditure per participant per course was $120. Approximately 54 percent of the adult education courses were provided by schools; the remainder were offered by industry, community organizations, government agencies, and others. ’s

Industry and Labor-Provided Instruction

Two important components of the U.S. instructional system whose activities are not fully captured in the description of enrollments provided above are industry and the labor movement. While there are no data on total enrollment in industry-based instructional programs, the American Society for Training and Development estimates that the private sector spends between $30 billion and $50 billion

“National Center for Education Statistics, op. cit., 1983. According to NCES, some 27,000 different institutions offered vocational education programs in 1978-79. Over half of these institutions, or 15,700, were publicly fimded comprehensive and vocational secondary schools. The second largest group of institutions offering vocational education programs, “private noncollegiate postsecondary schools, ” numbered 6,800 and included vocational/technical institutes and trade, health, and business schools. Also included among the providers of vocational education in 1978-79 were approximately 1,100 2-year and 600 4-year institutions.

“*Survey of Participation in Adult Education*, conducted by the Bureau of the Census for the National Center for Education Statistics, 1981.

*“For both 1978 and 1981, there was a direct positive relationship between the numbers of years of schooling and the rate of participation in adult education. Persons with an eighth grade education or less participated in adult education at a rate of only 2 percent in 1981. On the other hand, 31 percent of persons with more than 4 years of college had taken part in an adult education activity during the year. A little over 11 percent of high school graduates with no college experience participated in adult education, while over 26 percent of those with 4 years of college participated. The correspondence between higher educational attainment and greater participation in adult education was evident across all racial/ethnic groups, and was most notable among females. Within each racial/ethnic group, the more well-educated an individual was, the more likely he or she would participate in adult education activities. The relationship between greater attainment and participation was even more pronounced among females than among males. Male participation rates ranged from 2 percent for those with less than 9 years of formal schooling to over 28 percent for those with 5 or more years of college. While women with an eighth grade education or less participated at a rate of only 2 percent, those with 5 or more years of college participated at a rate of almost 36 percent, 8 percentage points higher than men with the same level of schooling. ” (National Center for Education Statistics, op. cit., 1983).

**In general the higher the income, the greater the rate of participation, In 1981, the participation rate for those with incomes less than $7,500 was 6 percent, while approximately 19 percent of individuals with incomes of $50,000 or more participated. Adults residing in metropolitan areas comprised 72 percent of adult education participants. Participation rates relative to population were higher for the Western States (27 percent) than for the North Central States (approximately 14 percent), the Northeast (10 percent), or South (11 percent).

[15]National Center for Education Statistics, op. cit., 1983.

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annually on such programs.* Unpublished Bureau of Labor Statistics (BLS) estimates suggest that in 1982 there were 287,000 persons enrolled in apprenticeship programs in the United States. This represents a decline of 33,000 since 1980.** While apprenticeship represents only one of a number of types of training offered by industry in cooperation with labor unions and labor organizations, there are no data available to measure the degree of labor involvement in nonapprenticeship instruction.

In summary, data available on enrollments in elementary, secondary, postsecondary, vocational, and adult education seem to show that while the numbers of participants under the age of 17 have been declining, there have been increases over the past few years in adult participation. However, given the high levels of educational attainment, high incomes, relative youth, and ethnic/racial makeup of those participating in instruction, individuals within the work force who are at greatest risk due to technological and economic change are those least predisposed to enrolling in courses that may lead to new skills development.

Changes in Emphasis

National recognition of the role that human resource development plays in continued economic growth is leading to changes in instructional priorities, especially for education and training that occurs prior to employment. New areas of emphasis that are already having an impact on curriculum are strong basic skills in math, science, and communication; and computer literacy.

Basic Skills

While there are skill requirements associated with particular workplaces that change over time, there are some types of skills so important that they are widely accepted as essential to individual and economic growth. Development of these skills within the individual serves as a foundation for higher order personal and career skills. Development of these skills is also necessary for exercising most rights of individual citizenship. The skills that comprise this group, commonly referred to as "basic skills, " have changed over time to reflect economic, scientific, technological, and social change. Basic skills as currently defined are under national scrutiny to determine how viable they are and whether there are additional skills that are now so critical to individual and national growth that they should be added to the core group.

Since the Colonial era, the need for basic proficiencies in mathematics, reading, and writing has been recognized by educators as a central goal of instructional programs for children and adults. With the creation of a public education system in the United States during the 19th century, the goal was to provide to all school-age residents of the United States, including recent immigrants who represented a significant portion of the manufacturing work force during the Industrial Revolution, the opportunity to develop these skills or proficiencies. These basic skills were to be developed in the primary grades and were to serve as the foundation for both the vocational and academic tracks established as a part of the 19th-century public school system.[16] [17]

Following the reemphasis on basic skills at the founding of the public education system, the next major reexamination of basic skills and their relation to occupational preparation occurred in the 1950's, when increased concern over national defense and a national commitment to manned space exploration led to the enactment of the National Defense Education Act.* This legislation encouraged secondary

*This is a rough estimate of the total, annual industry expenditure. ASTD is cooperating with the Department of Labor (DOL) to establish mechanisms for systematically gathering data on industry-based education and training activities,

**The program for tracking the numbers of registered apprentices on an ongoing basis was eliminated as a result of DOL budget reductions and program reorganization in fiscal year 1982.

[16] Lawrence A Cremin, *Public Education* (New York: Basic Books, Inc., 1976).

[17] Sol Cohen, "The Industrial Education Movement, 1906-17, " *American Quarterly*, vol. 20, No. 1, spring 1968, pp. 95-96.

*Some would argue that basic skills deficiencies that surfaced during World War II among American military recruits led to another national examination of how basic skills were being addressed in elementary and secondary education.

and postsecondary institutions to place additional emphasis on the development of strong science and math skills. The act also sought to increase the supply of scientists and technical personnel through individual scholarships and low-interest loan programs. During this period, recognition of the increasing importance of the sciences for vocational and occupational preparation and for understanding key national issues led to a redefining of "basic skills' to include a foundation in the sciences. And for a time, the development of strong basic skills in this broader sense was a national priority.

It is difficult to determine exactly when emphasis on the development of strong basic skills diminished. However, employers began to voice concerns about basic skills deficiencies in entry-level personnel in the early 1970's.

The change in emphasis on basic skills may have been related to the broad range of social issues that affected the educational system beginning in the mid-1960's. The list of mandates for the public education system grew rapidly in the late 1960's and 1970 's. Educational equity emerged as a top priority as a result of the urban crisis, recognition of high levels of unemployed minority youth, and the passage of Federal legislation requiring school desegregation. With the passage of the Elementary and Secondary Education Act, the public schools were charged with ensuring that equal educational opportunity was extended to various target populations, including minorities, the economically disadvantaged, and the handicapped. Perhaps with the resources and attention directed at this and other important new educational priorities, federally funded educational institutions may have inadvertently reemphasized basic skills development. Changing societal goals and values, as well as changing demographics, have presented challenges to educators since the turn of the century. And, at present, schools are caught between the requirements of an old society, with its inherent goals and values, and the requirements of an emerging, more technological society .18

Computer Literacy and the Basic Skills

In the 1980's, continued advances in information and communications technologies and the growing use of computers in the workplace, in education, and in the home have created an awareness of the value of a "computer literate" population. Computer literacy as a term came into use in the mid-1970's. Since that time, there have been a variety of interpretations of what it means to be "computer literate."[19 20] While computer literacy can encompass varying levels of knowledge of computer technology, it usually refers to basic keyboard skills, plus a working knowledge of how computer systems operate and of the general ways in which computers can be used. For example, Boeing Computer Services, a firm that offers nationally a range of courses relating to computer technology, covers the following topics in its "Personal Computer Literacy" course:

- computer terminology;
- computer manuals (documentation);
- computer keyboards;
- diskette organization;
- computer files; and
- general operating practices.

Based on the variety of environments within which individuals are affected by computer technology, as well as the importance of promoting understanding of science and technology within the general population, educators and others are once again revisiting the definition of "basic skills" and determining whether

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[18] William K. Elser, "The American School Dilemma: On the Upside of the Third Wave, " *The Clearing House*, October 1983.

[19] Ronald E. Anderson, "National Computer Literacy, 1980, " *Computer Literacy: Issues and Directions for 1985* (New York: Academic Press, 1982).

[20] Dorothy K. Dennger and Andrew R. Molnar, "Key Components for a National Computer Literacy Program, " *Computer Literacy: Issues and Directions for 1985* (New York: Academic Press, 1982).

it should be expanded to include computer literacy.

Critics of computer literacy as an instructional priority question its value to the population as a whole; they cite continuing advances in software technology that will increase ease of computer use and eliminate the need for formal instruction. For example, alternative input devices such as the light pen, the "mouse," and voice command are now becoming available and are particularly popular with workplace personnel who are uncomfortable with keyboarding, such as managers.[21] In addition, a major obstacle to achieving widespread computer literacy continues to be the high level of functional illiteracy in the U.S. population. Most recent estimates indicate that one out of five Americans lacks sufficient reading, writing, and math skills to perform such common, day-to-day functions as filling out a job application or handling personal finances. * The business community has become increasingly concerned about basic skills deficiencies among employees, including college graduates. These deficiencies represent major obstacles to professional performance as well as to continued professional advancement. In a recent survey of representatives of industry, trade unions, and local school systems, two-thirds of the industry representatives and the majority of the union representatives indicated that basic skills deficiencies in employees limit advancement opportunities. And, while the survey indicated that a variety of cooperative activities existed between industries and schools, there were few cooperative programs aimed specifically at basic skills development.[22]

"Craig Zarley, "The Wide World of Alternative Input Devices, " *Personal Computing*, February 1984, pp. 129, 131, 133-34, and 137.

*See reference to University of Texas study of adult illiteracy cited earlier in this chapter on p. 224.

"Center for Public Resources, op. cit., 1982.

Challenges Facing the U.S. Instructional System

Instructional providers are being asked to take on an increasing number of responsibilities relating to human resource development. First, they are faced with continuing efforts to upgrade the skill levels of the U.S. population as a whole–specifically through the development of basic language, reading, math, and science proficiencies. At the same time, they are charged with addressing the need for developing new skills and capacities, such as computer literacy and a basic understanding of science and technology within the general population. In addition, they must continually review programs and services relating to vocational and professional development in the light of economic and technological change. It is within this context that the instructional requirements for programmable automation must be examined.

Instructional Requirements for Programmable Automation

Some of the education, training, and retraining requirements linked to the use of programmable automation in manufacturing cannot be distinguished from instructional requirements linked to the increased use of advanced information and communications technologies in nonmanufacturing work settings—e.g., the need for a strong foundation of basic skills and for computer literacy is also linked to the use of computer-based technologies in public and private sector office work sites. Other current impacts on the U.S. instructional system are directly attributable to programmable automation and its effects on skills within existing manufacturing occupations—those within the production-line, technician, engineering, and operations management groups. It is this distinct set of PA implications for vocational and technical education, training, and retraining that will be the focus of this section of the chapter.

It should be noted that certain conditions limit this discussion of instructional requirements for PA. First, advanced manufacturing technologies are now in limited use. While PA adoption will increase, patterns of use to date have not led to investigations of skill requirements and accompanying instructional needs that go beyond what may be unique requirements of individual firms. Secondly, the literature on PA-related skills and on instruction for automated manufacturing environments is thin, consisting almost entirely of very general descriptions of individual courses or programs. Because of these limitations, observations made in this section of the chapter on instructional needs for PA are based in part on 14 in-depth case studies of 20 existing instructional programs that were prepared for OTA in conjunction with this assessment.

Instructional Requirements for Production Line Skills

For jobs common to production work in automated facilities, there appears to be a greater need to develop the ability to apply conventional manufacturing skills in new, more conceptual ways. For example, in a Cincinnati Milacron, Inc. (CMI) training program for employees of firms that purchase CM I computerized numerical control (CNC) equipment, operators learn to interact with the control panel and to monitor rather than constantly interact with the equipment. CM I instructors stress that while students, especially older machinists, need to learn to use their knowledge of machine operations (conceptual) more than they may have in the past, their knowledge of traditional machining operations (motor) will enable them to anticipate CNC machine motions and functions.[23] Overall, electronic control of production machinery of all types is expected to reduce demand for motor skills and increase the demand for conceptual skills.[24]

Instruction for some technician-level occupations is quite similar in some instances to instruction for skilled trades occupations (e.g., electricians and electronic technicians), given the similarities between certain skilled trades jobs and selected technician-level jobs. But where distinctions can be drawn-e. g., for robotics, programmable equipment field service, and NC part programing technicians-the focus of technician-level instruction is now on the development of multiple skills (greater skill breadth) and of an understanding of how programmable equipment interfaces with other components of the manufacturing process.

Traditionally, limited employer-provided instruction has been made available to semiskilled and skilled production personnel beyond apprenticeship and/or entry-level training. PA has resulted in more emphasis on training for semiskilled and skilled worker groups. For example, like many other General Motors' facilities, the "S" Truck Plant examined in an OTA case study had had no formal mechanisms for delivering in-plant, classroom and laboratory training to shop floor workers prior to the installation of programmable equipment in 1980. Since the plant education and training department staff lacked the technical expertise to provide such instruction, training for shop floor workers took the form of on-the-job training or was provided by equipment vendors. The plant's "New Technology Training Program" established a permanent technical training group and created an awareness among plant management of the need for an in-plant training/applications lab that included equipment designated for training purposes.[25]

Production personnel responsible for equipment/systems operation, and/or maintenance and repair most often receive their training from vendors of programmable equipment and systems. Through these programs, production

[23] Cincinnati-Milacron case study, 1983.

[24] Barry Wilkinson, *The Shopfloor Politics of New Technology* (London: Heinemann Educational Books, 1983).

[25] General Motors case study, 1983.

staff, along with all other types of manufacturing personnel, are oriented to general equipment/system features and operation. Rarely is the training designed to address the unique applications within a particular plant or facility.* There are exceptions among vendors, however. Cincinnati Milacron, for example, offers formalized customer training courses for its NC and CNC machines and robots, but will also develop instruction geared to particular customer applications and will provide training design consulting services on request.[26] All five companies studied who were producers of programmable equipment or systems —including Computervision, CADAM Inc., Cincinnati Milacron, Inc., GCA, and Automatix--provide informal on-the-job training to customers on an as-needed basis to supplement instruction provided at installation. Formal training programs range from 2½ days to 3 weeks.

Both producer- and user-provided training for production personnel stresses how to operate, monitor, maintain, and repair programmable equipment or systems. In-plant courses examined which were provided by user firms were very narrowly focused and intensive, with training periods of 1 to 2 weeks.[27]

In some instances, PA-related training for skilled production personnel with some previous exposure to electromechanical technology is broader in scope. Presumably, these workers are graduates of apprenticeship programs and have broader skills on which to base instruction. For example, the International Brotherhood of Electrical Workers' Local 11 Electrical Training Trust in Los Angeles County, Calif., provides voluntary training to journeymen electricians on the installation and maintenance of programmable controllers. The training is designed to develop in enrollees who possess a background in electricity an understanding of electronics technology-a related but separate discipline.[28]

Community colleges take a variety of approaches to technician-level instruction for PA—from single courses to 2-year associate degree programs. Henry Ford Community College (HFCC) in the Detroit area offers an "Automation/Robotics Option" within its 2-year Electrical-Electronics Program. Among the subjects covered are programmable controllers and other computer-aided manufacturing (CAM) equipment. HFCC has also developed several courses on programmable controllers geared to the needs of union apprentices and journeymen. Glendale Community College in Los Angeles County operates a short-term industrial training program on computer-aided design (CAD) in conjunction with local industry and government. Both HFCC and Glendale encourage students to continue their education beyond the associate-degree level by indicating courses that could be applied to a 4-year bachelor of science degree.[29] [30]

There are some attempts under way to develop a standardized curriculum for technician-level occupations within the field of programmable automation. The advantage of the core curriculum is that it develops a broad foundation of knowledge on which to base subsequent PA instruction during the same instructional period or at a later date. For example, the Center for Occupational Research and Development (CORD), a nonprofit organization that develops instructional materials for emerging technical fields, has developed a core curriculum to which components for robotics, computer-aided drafting, or laser technology can be added. The core curriculum seeks to develop interdisciplinary skills, including:

*This was one important finding of the OTA-sponsored survey of views of education, training, and retraining for programmable automation. For more information on the survey, see *Automation and the Workplace: Selected Labor, Education and Training Issues* (Washington, D. C.: U.S. Congress, Office of Technology Assessment, OTA-TM-CIT-25, March 1983).

[26]Cincinnati Milacron case study, 1983.

[27]In-plant, user firm training was examined at the following companies/plants: 1) a large aircraft manufacturer (asked not to be identified); 2) Texas Instruments; 3) CADAM Inc., a subsidiary of Lockheed Corp. and a producer of computer-aided design software; 4) Cincinnati Milacron, a vendor of robots, computer-aided machine tools, and machine controls; 5) a General Motors' "S" Truck Plant; and 6) Westinghouse Corp. 's Defense and Electronics Systems Center.

[28]International Brotherhood of Electrical Workers case study, 1983.

[29]Henry Ford Community College case study, 1983.

[30]Glendale CAD/CAM Operator Training Program case study, 1983.

Photo *credit: Los Angeles Electrical Training Trust*

These skilled electricians, members of Los Angeles Local No. 11 of the International Brotherhood of Electrical Workers, are attending a 6-week training program designed to develop the skills required to install, troubleshoot, and maintain programmable controllers. Since the training program was first offered in October 1981, 170 members of the Local have completed the program offered by the Los Angeles Electrical Training Trust. Forty-six have completed an advanced programmable controller course. Graduates are employed by contractors who install and maintain automated equipment i n manufacturing facilities. For more information on the Training Trust's programs, see am. A to this report, the section of this chapter entitled "Case Studies: Selected Instructional Programs, " and' p. 236 of this" chapter

- electrical,
- mechanical,
- fluidal,
- thermal,
- optical, and
- microcomputer technology .3]

Community colleges and vocational schools in several States—Ohio, Oklahoma, New Mexico, and Idaho—have adopted the CORD electromechanical curriculum as the standard for community colleges in their regions.

For the most part, PA instruction for technicians is developing along traditional lines. That is, PA-related courses are often simply added to existing curricula, such as electromechanical technology. While such programs may produce technicians qualified to operate in today's automated manufacturing facilities,

[31] Interview with Dan Hull. President, CORD, May 1983.

they may or may not equip individuals for future workplace change. Programs that develop a broad interdisciplinary knowledge base, that emphasize computer technology, and that impart a broad understanding of the system as well as its components are essential if individuals are to have the flexibility to face future PA-related change in the workplace.[32] One program that seeks to develop this broad-based understanding of the system and components is a Brigham Young University (BYU) 4-year engineering technology program, which is described in detail in appendix A to this report.

In two of the manufacturing facilities studied, Westinghouse Defense and Electronics Center and Texas Instruments, the training of shop floor personnel on automated equipment was linked to research and development activities. This link benefits researchers and production staff. Both firms have established manufacturing technology centers where the training of shop floor managers and workers who will utilize the technology once it is installed is conducted in conjunction with applications research. At both facilities, trainee involvement helps the researchers by providing information about shop floor-user needs and opportunities to test and utilize manufacturing technology in a practical environment. It also helps shop floor workers by allowing them to become familiar with the technology before it becomes a permanent part of the manufacturing process, and by enabling them to express their needs, concerns, and dissatisfactions prior to final system implementation.[33 34]

Instructional Requirements for Engineers

Design and production engineers who work in computer-automated facilities are required to have a broader based knowledge of engineering operations and stronger management skills than those who work in more conventional manufacturing plants. There is also much greater emphasis placed on understanding how PA may be most effectively applied. In keeping with these new skill requirements, some engineering schools are placing greater emphasis on hands-on experimentation and project-oriented instruction and less emphasis on the more traditional, theory-based instruction.

For example, Worcester Polytechnic Institute (WPI), a primarily undergraduate engineering and science institution, joined forces with Emhart Corp. in 1981 to form an on-campus research center. In addition to providing Emhart and other firms with a manufacturing engineering applications research capacity, the center offers engineering students the opportunity for regular contact with practicing engineers and with practical problems and situations in the form of industrial "projects." Two projects-one focusing on an application within the student major field and the other focusing on broad societal impacts of technology's application— are graduation require ments for all WPI students.[35]

BYU offers an engineering technology program with specialties in manufacturing, design, and electronics. All three of the BYU technology programs substitute application-oriented, laboratory-based courses for the highly theoretical coursework of traditional engineering programs. The goal is to combine a foundation in theory with practical applications experience. (See photo on p. 246.) Computer-aided design and manufacturing have been a part of BYU's engineering technology program since the mid-1970' s.*

Attempts are being made on the undergraduate and graduate levels to familiarize design engineers with manufacturing requirements and, conversely, to familiarize production engineers with design procedures. In addition, there is more emphasis being placed on developing the ability to take the entire design-man-

[32]Dan Hull, "What is High Technology?" *Developing High* Technology Vocational Programs, American Vocational Association and the Center for Occupational Research and Development, May 1983.
[33]Westinghouse Defense Electronics Center case study, 1983.
[34]Texas Instruments Corp. case study, 1983.

[35]WPI's Manufacturing Engineering Applications Center case study, 1983.
*A summary of th case study on BYU's Engineering Technology Program is included in app. A to this report.

ufacturing process into account—e.g., through the systems approach, which focuses on the integration of computerized systems with more traditional forms of automation. Students enrolled in BYU's master's program in computer integrated manufacturing are required to have at least 1 year of industrial experience. They are free to pursue either CAD or CAM as an option within the program, but are required to take courses from each specialty area and learn to integrate computerized systems to solve practical, recurring industrial problems." The University of Michigan's College of Engineering, although more traditional in its approach to undergraduate engineering education than some of the other schools studied, offers students a graduate-level program in integrated manufacturing. In 1981, the Engineering College established a Center for Robotics and Integrated Manufacturing (CRIM) in order to coordinate and expand research and teaching activities relating to computer-based automation. In 1982-83, a total of 45 graduate students participated in CRIM-sponsored research projects.[37]

The effects of programmable automation on engineering education will depend on the approaches taken to engineering instruction within individual educational institutions and programs. If the more traditional approach is taken on the undergraduate level—i.e., a focus on developing an extensive, theoretical framework on which to base practical experience—then PA will represent more of a force for change in graduate and continuing education programs. If individual institutions place greater emphasis on combining theory with practice in undergraduate engineering education, and in so doing emphasize CAD and CAM, then advances in PA research and applications will continue to trigger curriculum change on the undergraduate level. The variety of approached currently being taken to programmable automation in engineering education does suggest that individuals preparing for careers in engineering should be aware of the lack of standard approaches to curriculum content. The mix of theory and application, as well as the exposure to programmable technologies, differs from school to school. Regardless of approach, a critical need for education is to ensure that engineering laboratories and curricula reflect the state of the art of the technology .38

"Brigham Young University case study, 1983.

"University of Michigan case study, 1983.

Instructional Requirements for Managers

There has been concern within industry for some time about the lack of management expertise in technical personnel. Indeed, some observers suggest that industrial managers who are cautious and detail-driven, coupled with a corporate decisionmaking process that stresses short-term financial considerations over the potential for long-term gain, have substantially delayed redesign and retooling of the U.S. manufacturing sector.[39] Traditional engineering programs have not stressed the need for the development of management competencies, nor have traditional management education programs offered special courses geared to the needs of technical and engineering operations managers. A recent report of The American Assembly of Collegiate Schools of Business, the accrediting body and professional organization for the deans of approximately 600 undergraduate and postgraduate business schools in the United States, recommended that business schools address criticisms of overemphasis on finance and marketing in their curricula by giving equal weight to production processes and productivity ."' Professor Tom Lupton, director of the Manchester Business School, University of Manchester (United Kingdom), who has conducted a study of management development pro-

[38] Donald D. Glower and Linden Saline, *A Response to Advancing Technologies: Repositioning Engineering Education to Service America's Future* (Washington, D. C.: American Society for Engineering Education, 1982).

[39] Wickham Skinner, "Wanted: Managers for the Factory of the Future, " *ANNALS, AAPSS, No. 470,* November 1983, pp. 102-114.

[40] *Report on U.S. Productivity and International Competitiveness,* sponsored by The American Assembly of Collegiate Schools of Business at George Washington University, Washington, D. C., June 13-16, 1983.

grams in Western Europe, made these observations:

> ... Management education everywhere—in Europe and North America certainly-has suffered from the attempt to bring the world into the classroom rather than to take the teacher (or rather the organiser of learning) into the fields of action. However, it is encouraging to notice the beginning of a shift from the passive to more active modes of learning. . . . Yet although the shift is happening in many schools, movement is slow.[41]

The need for managers of automated manufacturing facilities and other complex operations to possess an understanding of the total manufacturing system and all of its components has led some universities to create new master's degree programs in technical management. The University of Pennsylvania's Wharton School has instituted a program entitled "Management and Technology "-a joint venture between Wharton and the University's Engineering School. The Sloan School of Management at MIT also offers a graduate program in the management of technological innovation. Yale University, too, has established an engineering management program on the graduate level—a joint venture between the engineering and management schools. And in the fall of 1983, BYU's Technology Department began to offer a graduate degree in technical management as a cooperative effort between the College of Engineering Sciences and the School of Management.*

Some universities are going beyond the disciplines of engineering and management to include an even broader base in their manufacturing engineering curricula. With the aid of a 4-year, $2 million grant from the IBM Corp., Lehigh University of Bethlehem, Pa., is launching a graduate-level manufacturing systems engineering program that will integrate "systems perspectives with interdisciplinary education and training" and combine academic coursework with "industry-oriented internships, laboratories, simulations, plant inspections and projects. "[42] Lehigh is one of five universities benefiting from multimillion-dollar IBM grants to encourage the establishment of manufacturing systems engineering programs. UCLA's School of Engineering and Applied Science draws its graduate-level manufacturing engineering curriculum from the disciplines of materials science, mechanics and structures, computer science and engineering, electrical engineering, and engineering systems.[43]

Segments of the training industry and professional societies are also becoming aware of the interest in and need for technology management courses for engineers and nontechnical personnel employed in automated manufacturing facilities. Boeing Computer Services (BCS), a subsidiary of the Boeing Co.—a producer of commercial and military aircraft–is an established provider of technology-based training to commercial firms and Federal, State, and local governments. BCS is test-marketing a seminar for managers to provide them with information on the basics of CAD and CAM systems and related terminology; as well as a primer on computer graphics and the use of CAD and CAM software. Also covered in the seminar is a step-by-step approach to managing a CAD and CAM project, including:

- considerations for purchasing hardware,
- methods to ensure efficient system use to achieve maximum productivity,
- procedures for defining training requirements and implementing a training program,
- procedures for choosing proper systems applications for a particular environment, and
- procedures for establishing a data management system.[44]

[41] Tom Lupton, *Management Development in western Europe* (Manchester, U. K.: Manchester Business School, 1982).

*For additional information on this program, see the Brigham Young University case study, included in app. A to this report.

[42] B. Litt and M. Groover, *Developing Manufacturing Systems Engineers for the Future: A Unique Industry-University Joint Venture*, paper presented at the American Institute of Decision Sciences, Southwest Conference, Feb. 29, 1984.

[43] Vic Cox, "Materials Science and Manufacturing Engineering: The New Alchemy," *The Minority Engineer*, winter 1984, pp. 17, 20, and 22.

[44] Information provided by Boeing Computer Services, 1983.

To date, six courses have been delivered, with a total of 180 managers enrolled. Trade and professional organizations, such as the Society of Manufacturing Engineers, offer short courses in technical management to their members and other interested individuals, often in conjunction with national and regional conferences.

It is too soon to judge whether these technology management programs and courses constitute the beginnings of a trend. However, continued industry pressure for more effective technical managers may well lead to greater emphasis on the development of management skills in industrial engineering and computer science programs.

Case Studies: Selected Instructional Programs

The instructional system in the United States is a loose confederation of institutions, agencies, and organizations from the public and private sectors. The intent of the programs designed and delivered by these instructional providers varies widely. This is no less true for instructional programs that are designed to develop skills required in automated manufacturing facilities. Within this section of the report are included highlights of findings of an in-depth examination of 20 instructional programs for automated factory environments. These programs are representative of relatively successful efforts initiated by secondary and postsecondary educational institutions, vendors of programmable equipment and systems, users of programmable automation, labor unions, and Federal and/or State-funded retraining facilities. Cooperative instructional programs of various types are also featured. These findings also shed some light on the strengths and shortcomings of currently available instruction, problems encountered in program design and operation, and the roles assumed by educators, industry, labor, and government in these innovative efforts—roles that may be representative of emerging roles for these sectors within the instructional system as a whole.

To supplement this discussion of trends and patterns in PA-related instruction, appendix A to this report contains summaries of five of the case studies developed:

- a robotics and computer-aided drafting program for high school students, operated by the Oakland County school system in southeastern Michigan;
- the undergraduate and graduate degree programs in engineering technology offered by BYU, Provo, Utah;
- CADAM Inc. 's* customer training in computer-aided design;
- the Los Angeles Electrical Training Trust's programmable controller training program; and
- the "CAD/CAM" operator training program, at Glendale Community College, Glendale, Calif.

Appendix A also contains a brief description of the case study methodology.

Findings: Roles, Functions, and Capacities of Programs

The findings listed below are based on the universe of 20 programs encompassed in the 14 case studies. It should be emphasized that, even though careful consideration was given to ensuring variety and comprehensiveness of program types, the findings are limited by the size of the sample. Therefore, while certain general conclusions can be drawn, these are based solely on the scope of the programs investigated.

Primary Education.—One primary program was examined: the Dallas Independent School District's Project SEED. It emphasizes building basic mathematics skills and interest in

*CADAM Inc. is a subsidiary of Lockheed Corp.

mathematics as the foundation for further technical studies. Because the program can reach all school-age children in the district, it has the capacity to achieve an extremely broad impact by increasing the number of students capable of and interested in more advanced educational programs focusing on PA and other technological fields.[45]

High *School* Education2.-Two high school programs were investigated: the Dallas Independent School District's Science and Engineering Magnet School; and the Oakland County, Mich., robotics and computer-aided drafting programs. Programs examined either focus on or include computer literacy, pre-engineering, basic computer science, computer-aided drafting, and robotics. Career awareness is also stressed. The programs examined indicate that PA studies can be introduced effectively at the high school level, especially if orientation to computer-aided techniques is stressed as part of a comprehensive vocational education program focused on core trade skills.[46] 47

Community Colleges.–Henry Ford Community College (Michigan), Eastfield Community College (Dallas), and Glendale Community College (Los Angeles County) were the sites studied. The major functions of their programs are: 1) granting 2-year associate degrees (or degree options) focusing on or including robotics or computer-aided design, and 2) offering short-term work-study training programs jointly operated with industries and government agencies for students with previous college-level technical coursework. Also included among community college functions are career counseling and agreements with local universities to enable students to proceed directly to B.S. programs. The 2-year colleges studied are all characterized by responsiveness to industrial skill needs and coordination with local industries on such matters as curriculum content and equipment needs. Major strengths are the practical orientation of the technical programs, the industrial experience of the instructors (usually a hiring requirement), and their balancing of the needs of the students and the community at large with industrial demands for specific skill preparation. The colleges' focus on practical, technician-level coursework makes them excellent vehicles for responding to the growing need to retrain displaced workers. Major weaknesses stem primarily from lack of adequate funding to purchase industrial-quality equipment and build needed laboratory facilities.[48]

Um"versi'ties. -The examination of the university's role in PA instruction focused on four engineering and technology programs: 1) University of Michigan; 2) Brigham Young University; 3) Texas A&M University; and 4) Worcester Polytechnic Institute. University approaches range from: 1) introducing PA studies as a major focus (CAD) or minor option (CAM) in 4-year technology programs that substitute practically oriented coursework for the most theoretical of the courses required in engineering curricula; 2) introducing CAM into undergraduate curricula through projects with industry or projects that simulate industrial conditions, plus the use of innovative instructional techniques that enable engineering undergraduate students to begin to focus on CAM at that level; to 3) reserving the focus on computer-aided manufacturing (or, computer-integrated manufacturing) for graduate-level programs so that undergraduates may first master the fundamentals of traditional engineering disciplines. In the three universities studied in depth, * computer-aided design is more comprehensively covered in undergraduate engineering or technology curricula than is computer-aided manufacturing.

The research functions observed at universities, and the capacity to engage in PA research, are equally varied, ranging from industrially oriented applications research to long-term research aimed at areas of potentially high technical or economic impact where success is uncertain. While the latter type of

"Texas instruments case study, 1983.
"Ibid,
"Oakland County case study, 1983.

"Henry Ford Community College, Texas Instruments, and Glendale CAD/CAM Program case studies, 1983.
*University of Michigan Brigham Young University, and Worcester Polytechnic Institute, case studies, 1983.

research may fill a need that many industries do not have the luxury to address, the former more effectively fills industry's short-term needs. * As in the cases of the high school and college programs, most university programs are limited in capacity by less-than-adequate funding, equipment, and laboratory facilities.[49]

Apprentice and Journeyman Traing.-The major function of the union training programs observed—both of which serve industrial electricians-is to build PA training onto a solid core of fundamental trade skills either during the final year of apprenticeship training or in voluntary or company-sponsored journeyman training.'" Union-sponsored or oriented programs observed differ from university and some college programs in that they are not designed to place technology studies in the context of broad-based humanistic education. However, the union programs concentrate more on the development of a given individual's skills than in-plant training programs generally do (see below). Whereas most in-plant training focuses on task-oriented skills required to perform a specific job, the union programs focus on adding PA-related skills to the complete range of skills required to perform as a journeyman in a specific trade.[51]

In-Plant Industrial Traing.–All of the in-plant training programs observed[52] provide job-specific classroom-laboratory training focused on the precise applications needs of the plant. A broad range of machine- or system-specific programs were examined along with overall systems orientation training for managers. In-plant programs are both efficient and effective because they are: 1) specifically focused on well-defined applications needs; 2) delivered to students grounded in both plant procedures and core trade skills who can put their new skills into practice immediately and continuously; and 3) more user-oriented than other types of PA training, since the trainers are normally in close contact with system users, programmers, and maintenance personnel and usually have current or previous plant experience in those fields. However, the streamlined efficiency of in-plant training limits its range: students normally learn only what they need to know to perform their jobs, and no more. Some in-plant training is also limited by a lack of resources devoted to or available for training.

Vendor Training.–The major function of the instructional programs delivered by producers or vendors of PA equipment and systems is machine- or system-specific training which is usually not application-oriented. * Such programs generally are not designed to do more than give customer trainees a thorough orientation to the equipment itself and the basic skills required to use it; advanced vendor training courses impart greater depth of maintenance skills, and some advanced training focuses on generic applications, such as welding or line-tracking (in robotics) and mechanical design or printed circuit board design (in CAD). Some PA vendors, such as GCA Corp. (semiconductor equipment, remotehandling and large-scale robotic systems), offer several levels of structured courses in key areas such as maintenance. Other vendors, such as Computervision (CAD hardware and CAD and CAM software) and Automatix (robotics and vision systems) will develop, on request and for a fee, customized, advanced courses .63

*See the later section on "cooperative Industry-Education Programs" for discussion of mutual benefits derived from joint education research projects.

"University of Michigan, Brigham Young University, Worcester Polytechnic institute, and Texas Instruments case studies, 1983.

"international Brotherhood of Electrical Workers Programmable Controller Training Program.

[51]International Brotherhood of Electrical Workers case study, 1983.

[52]Texas instruments; an aircraft manufacturer (asked not to be identified); CADAM Inc.; Cincinnati Milacron; and Westinghouse Defense and Electronics Center.

*The five companies profiled are: 1) Computervision, a vendor of computer-aided design systems (both hardware and software); 2) CADAM Inc., a software-only vendor, most of whose CAD software is sold to purchasers of IBM hardware; 3) Cincinnati Milacron, Inc., a producer of computer-controlled machine tools, robots, and other products; 4) GCA, a producer of specialized automated semiconductor equipment; and 5) Automatix, a vendor of custom-designed robotic and vision systems. With the exception of Cincimati Milacron (CMI)–which was founded in the 1880's and began producing computer-controlled machinery in the 1960's and 1970's—the vendor firms are relatively young companies. GCA and ComputerVision were established in the late 1960's: Automatix was created in 1980: and CADAM was incorporated in 1982.

[53]New England Programmable Automation Customer Training case study, 1983.

The expense of vendor training is another limitation.* Specific strengths include: 1) a high level of responsiveness to customers' needs, 2) increasing amounts of attention to developing and utilizing instructional methodologies that attempt to combine flexibility with a systematic approach, and 3) an increasing emphasis on the need for in-plant instructor training, manager training, and executive seminars, all of which stress the systems approach to manufacturing and design. The "systems approach, " which takes the entire design and manufacturing process in a given environment into account, is especially important in companies that now have or are in the process of building an integrated CAD and CAM database.

Cooperative Industry-Education Programs.– While all of the educational programs covered in the case study series have involved a degree of participation from other sectors, only five of the programs could be characterized as joint ventures in which government agencies and/or industrial firms have assumed a high degree of involvement in program operation. Those are: 1) the Glendale High School CAD program, 2) the Glendale coordinated funding pro gram, 3) the Eastfield College printed wire board program, 4) WPI'S Manufacturing Engineering Applications Center, and 5) the Texas A&M integrated circuit design program.

A number of the cooperative programs examined have the potential to increase the educational and/or research capacity of the academic partners, especially those programs that provide equipment and/or laboratory facilities which the school could not otherwise afford. In addition, such programs can provide the industrial partner with education and research services that industry is not organized to provide (e.g., PA-related training delivered in the context of a broad-based education, and a production-free environment in which to conduct applications research). The majority of the joint programs also give the industrial partner access to faculty and to potential employees (i.e., the participating students) who are either specifically trained in occupations in demand by the company or who have some familiarity with company procedures and requirements through participation in joint research projects.

Needs, Problems, and Trends Common to Industry and Education Programs

Summary

Neither the industrial nor the educational sector alone has fully met all PA training needs identified to date, nor has either solved all of the major problems associated with the delivery of such training. Some of those needs and problems are, in fact, common to both industrial training and the instruction delivered in educational institutions.

Common Needs

Long- and Short-Term Strategies. — While industrial organizations need training strategies that meet both short- and long-term needs to support PA implementation and expansion strategies, educational institutions must plan to meet short-term educational needs as best they can despite the difficulty of obtaining equipment and laboratory facilities. Texas Instruments has recognized both needs and supplements its in-plant training activities with extensive involvement in local elementary, secondary, and postsecondary education programs, plus cooperative arrangements with colleges and universities in Texas and elsewhere.[54] At the same time, educational institutions must engage in long-term forecasting and planning consistent with their own educational and research goals and future industrial needs. The University of Michigan, for example, has a long-range goal of strengthening its independent research and development and engineering programs, while continuing to re-

Vendors and producer in some cases in some cases Offer volume discounts, group discounts, and/or free training slots with purchase of their equipment. But vendor-provided training, while essential with initial purchase of equipment, becomes too expensive as a continued source of instruction. In the case study sites examined, neither vendors nor producers feel that it is a substitute for users establishing in-house training capacities.

"Texas Instruments case study, 1983.

spend in the short term to changing industrial skills requirements.[55]

Increased Internal Coordination. —The need for increased coordination between design and production departments in industries that either have developed or plan to develop a common CAD and CAM (or computer-integrated manufacturing) database is paralleled by the need for educational institutions to increase the coordination among departments engaged in interdisciplinary research and/or teaching activities. For example, Brigham Young University is working to establish closer ties between its engineering, technology, and science programs in light of the common effects of programmable automation on these courses of study, as well as the need for an interdisciplinary approach in many courses.

Increased Communcation.— Enhanced communications networks are needed not only within individual schools and plants, but also between industry and education; among companies engaged in producing, implementing, or expanding programmable automation; and among schools offering PA studies. In the case of the Glendale, Calif., CAD/CAM Training Program, State-level coordination and sponsorship provided both the impetus and the funding resources necessary to give Glendale College and other colleges (or, in some cases, consortia of colleges) participating in the effort, the opportunity to establish high-technology programs.

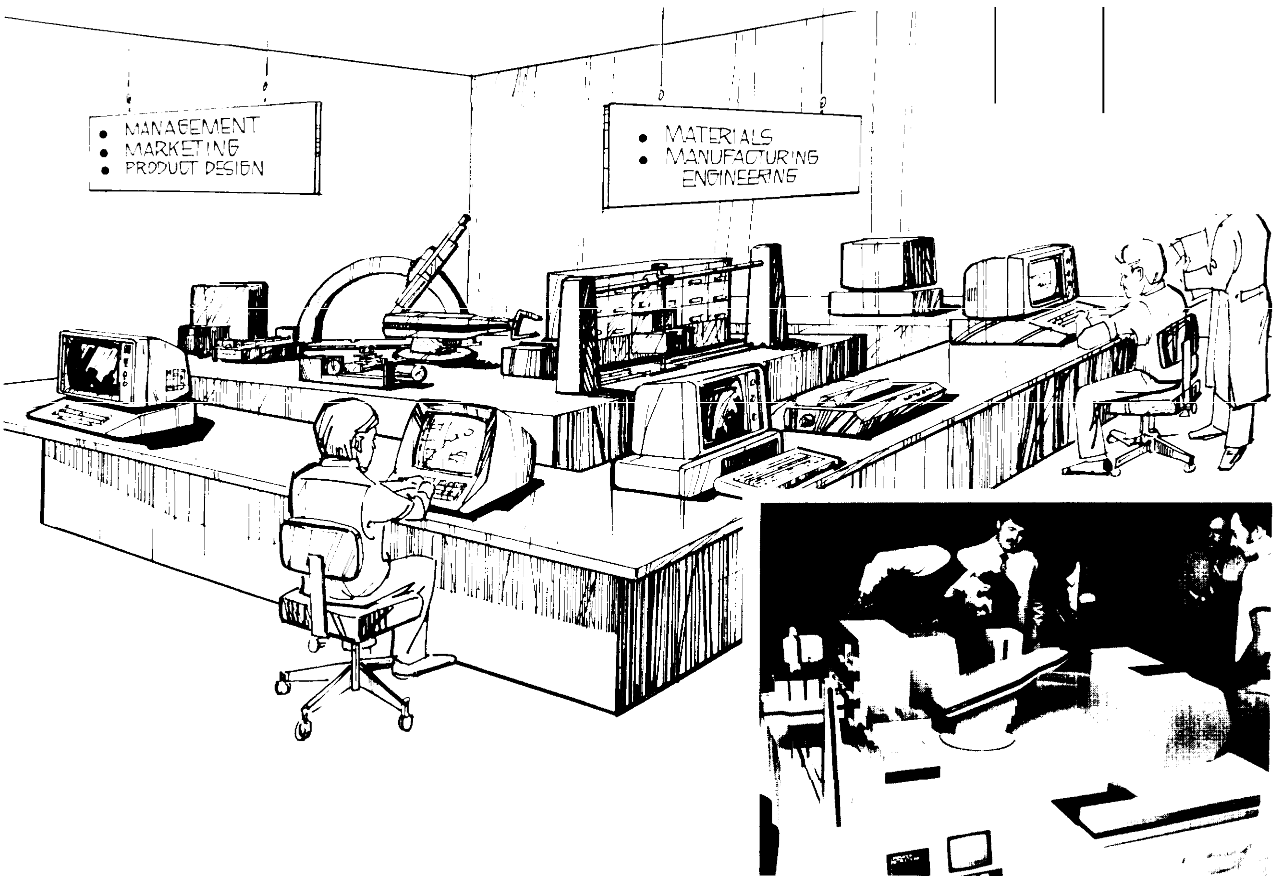
The object of the State-level sponsors was to demonstrate the feasibility of coordinating both funding sources and public and private organization efforts to support employment and training projects which would also build the educational capacities of the participating schools. The State-level coordination was also a pilot test of the abilities of State agencies to improve local responses to high-technology education and training needs by pooling and coordinating their resources. On the local level, the success of the Glendale program in meeting its goals was aided by the previously established linkages between the college, the Private Industry Council (PIC), and local business and industry.

In addition, prospective students and workers need to be informed about the specific programs offered in particular schools and the present and future skill requirements of the workplace. There are organizations that gather and compile information on programmable automation and other high-technology curricula which can be used by students or workers planning further education.* What appears to be needed, however, is a national mechanism for tapping the resources of the already existing organizations and gathering information from schools and industries that may not yet be included in the numerous studies and unofficial networking done by existing organizations. As important as gathering information on curricula, training methodologies, research, equipment needs, local problems, and local solutions is a mechanism for publicizing that information to teachers, prospective students, and workers who may not even know of the existence of established information organizations. A well-publicized national communications network would enable students to make informed choices of schools that meet their individual needs. It could also make curricular materials from a variety of sources available to schools and industrial training departments.

Exchange of Expertise Between Education and Industry. —The curriculum-development and teaching expertise of instructors in colleges and universities can be of help to industrial trainers facing the onset of increased in-plant classroom and laboratory training for programmable automation. Similarly, colleges

[55] University of Michigan case study. 1983.

*Numerous professional societies—such as the Society for Manufacturing Engineers and Computer-Aided Manufacturing International-enable professional engineers to exchange information on state-of-the-art techniques and problems. In addition, engineering education associations and vocational training societies spread information among educators and trainers. Conferences such as that held by Brigham Young University for universities engaged in PA teaching and research also help. AS wide-reaching as these organizations may be, however, they are still limited in that not all trainers and educators can afford the time or receive the funding to attend meetings.



This is a scale model (inset) of the group technology cell that will be a part of BYU's "CAM Mini-Lab. " **The model** was **built** in the University's Research Laboratory (see caption below)

Brigham Young University's Engineering Technology Department is creating a "CAM Mini-Lab"- a scaled-down version of a highly automated manufacturing facility—for use with students enrolled in "Computer-Integrated Manufacturing" and other courses offered through BYU'S Design Technology and Manufacturing Technology degree programs. The "Mini-Lab" is expected to be completely operational in the next 8 months and will be located in the CAM Software Department. Students are building most of the equipment for the lab themselves, including controllers, an automated storage and retrieval device, and a group technology cell that includes a lathe, a mill, and a robot. Once completed, BYU hopes to market the "Mini-Lab" concept to other schools of engineering and technology. For more information on BYU'S Engineering Technology Program, see app. A

and universities can benefit from having their students participate in simulated or actual industrial projects.

As one model for such interaction, the specific roles played by company and school representatives in WPI'S Manufacturing Engineering Applications Center (ME AC) projects are as follows: Emhart Corp. supplied all the equipment (including the robots themselves and the peripheral equipment needed to develop the applications) and transported it to WPI; covered all major project costs (which, aside from equipment, included administrative costs, equipment maintenance, and a portion of WPI staff salaries); assigned a project manager to be responsible for the overall operation of the various applications projects; and assigned other engineers and factory workers to aid in the research and development. WPI pro vialed laboratory and office space for the resident Emhart staff; a project administrator; students, faculty, and "resident engineers" specially hired to work on the MEAC projects; workshops, demonstrations, and tours for company personnel; and tuition-free coursework for participating engineers who wished to take advantage of the college's educational programs (including work toward M.S. and Ph. D. degrees).

Top-Level Organizational or Institutional Support and Self-Motivated Action by Instructors.– Well-planned and executed training and education requires active support by corporate management or school administrators. The corporate vice president who conceived of and initiated the WPI manufacturing engineering program enlisted top corporate support and acted as an arbitrator between the school and the company and between Emhart corporate and divisional employees when the need arose. Apart from top-level support, the need for individual instructors in educational institutions who take action by developing curricula, making industrial contacts, and keeping themselves abreast of the state of the art is matched by the need in industry for training directors or managers who can convince top management of the need for training to keep pace with PA expansion.

Flexibility. –Both industry and education need the flexibility to incorporate the new training and education needs into traditional practices and procedures. This may, in some instances, require restructuring curricula in educational institutions and restructuring training practices (or instituting new training procedures) in industry. When the need for instruction of production line personnel in the use of programmable equipment arose at the General Motors' "S" Truck Plant, for example, staff in the maintenance department were identified to serve as instructors and a permanent technical training group was formed.[5G]

"General Motors case study, 1983.

Jointly Sponsored Industry-Education Programs. -Joint programs with industry can significantly increase the capacities of educational institutions to conduct programmable automation education and research programs. While many industries have difficulties freeing equipment or laboratory facilities for student use, others that have been able to do so (e.g., JPL, Singer Librascope, and Emhart,) have seen a return on their investment that takes a variety of forms—ranging from free coursework for company engineers, to assistance in industrial projects, to company-specific training of potential or current employees. Some far-seeing company representatives also recognize that by building the capacities of the schools, they are bettering their future chances of hiring well-educated employees. Some also believe that colleges can potentially save companies training dollars by delivering in-plant training. In most cases, the companies would first have to train the college instructors in their procedures and practices, but industry supporters of contracts with colleges for training maintain that this would be less expensive than company-operated training, and that it has the added advantage of aiding industry and academia at the same time.

Common Problems

Lack of Adequate Resources.– While the lack of adequate funding, equipment, and laboratory facilities for training is most notable in the education sector, this problem has also been observed in some vendor and user firms. A significant implication is that those industries having difficulties filling their own needs for equipment, instructors, and facilities are hardly in a position to aid schools looking to industry for equipment. The national crisis in education that has been receiving increasing attention in the media and in numerous reports appears to be paralleled by the less publicized problem of the low-priority status of training in many industrial organizations. Nevertheless, as the successfully operated industry-education programs illustrate, resources (including equipment and laboratories

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in industry and the instructional expertise of educators) can be shared; Federal, State, and local government agencies can help to facilitate that sharing of resources by providing additional funds and by creating linkages–as was done on both the State and local levels in the instance of California's coordinated funding Project.[67]

Resistance to Change.–A number of industry and education representatives have pointed out that many individuals in their own organizations and institutions exhibit a strong resistance to the changes that maybe brought about by programmable automation and other emerging technologies. Not only individuals, but entire organizations show this resistance. While over-responding in an ill-considered fashion is certainly a danger, the traditionally gradual change in education and training makes a failure to respond in time a more prevalent-and likely—problem.

Keeping Up With the Constantly Changing State of the Art.–While many educators have difficulty keeping up with industrial advances in technology, and while postsecondary educational institutions as a whole face extreme difficulty in keeping their laboratory equipment up-to-date, industrial trainers (especially in vendor firms) face similar difficulties in keeping up with software updates and new releases of both software and hardware. The solution to this problem, as to so many others, is increased resources allotted to educational institutions and industrial training organizations so that they can hire more trainers, curriculum specialists and, in the case of educational institutions, more faculty to reduce the strain on the departments as a whole. The "solution," however, is a problem in itself, since training resources appear to be scanty in many industrial firms, and funding is a perennial problem in most schools.

Findind and Keeping Instructors.–High school, college, and university instructors who have developed PA expertise are attractive to industry, and must be dedicated teachers to pass up the allure of higher industrial salaries. Many potential instructors never consider pro fessional academic careers for the same reason, leaving the university immediately after completing their studies. Industrial training departments, especially in vendor firms, have similar problems. One potential solution lies in industry contracts with schools for exchanges of expertise, such as those described earlier. This approach can lead to enhancement of the professional competence of instructors.

Common Trends

Cross Training and/or Interdisciplinary Studies Plus the Systems Approach for Eng"neers and Managers. –Technical colleges and high schools stress the need for interdisciplinary coursework, especially in robotics and other programmable automation studies. This parallels the cross training of mechanics, electronics technicians, and other technician-level workers and maintenance personnel in plants where union provisions do not preclude workers from crossing occupational trade boundaries in the work performed. In some union plants that have such restrictions (e.g., where electrical maintenance personnel do not perform mechanical maintenance functions), inplant training courses often provide familiarity with those portions of the system not directly the responsibility of the individual mechanical or electrical maintenance worker. The systems approach to computer-integrated manufacturing studies offered by some engineering schools is, perhaps, paralleled by inplant training in CAD and CAM networking systems and by systems overview courses for managers.

Technical Management Education and Training.–Overview courses for managers are becoming more common, as are new master's degree programs in technical management for engineering personnel. Some of the universities studied, such as the BYU, combine coursework for a master's degree in business administration with graduate-level engineering or technology courses (often focusing directly on programmable automation) to produce trained technical managers.

[67] See case study 5: CAD/CAM Operator Training Program, included in app. A to this report.

Increased Attention to the Relationship Between Education-and-Trm"m"ng and Productivity.—This trend is related to the growing emphasis on lifelong learning. A large number of in-plant trainers and managers interviewed equated ongoing in-plant training with increased plant productivity. One of the major selling points of vendor training is that adequate instruction is required to enable workers to make the most productive use of CAD equipment and to keep CAM equipment operating at peak efficiency. Trainers in the union-operated training program studied were, perhaps, the most explicit of all. Said one: "The only thing we have to sell are our skills and knowledge—these must be pertinent if we are to continue to function as productive workers in a changing field."* Educators concerned with the personal productivity of their students after they leave school emphasize the necessity of continuing the learning process after formal education is completed. Programs offered by Worcester Polytechnic Institute, for example, are specifically structured to produce students who are capable of "learning to learn for themselves in a professionally competitive atmosphere. According to one WPI representative, "the net result is that, if the program succeeds in meeting its goals with individual students, those students who become practitioners have an infinite half-life as engineers, instead of the currently predicted l-year half-life. "

Career Guidance and Programmable Automation

Earlier in this chapter it was pointed out that the increasing use of programmable automation in manufacturing environments, along with other forces at work in the economy, is causing individuals and employers to develop new expectations and requirements for services from the U.S. instructional system. One of the expectations shared by individuals and employers alike is that there will be more comprehensive educational and career guidance programs accessible not only to children and young people, but also to adults. As increased use is made of advanced automation in the plant and the office, skills requirements will change and the emphasis on developing abase line familiarity with advanced technologies–especially the computer—will increase. In turn, the variety of career options and modes of *career* preparation will change.

Given an era in which lifelong education will be a necessity for most if not all participants in the U.S. work force, there will be an increasing need for educational and career counseling for adults. And in some cases, career counseling for adults may be an alternative to education and training, as has already been demonstrated with some displaced workers who possess marketable skills. To date, there has been no research yielding specific recommendations for altering guidance and counseling programs in accordance with the increased presence of advanced technologies in the American workplace. Yet the potential for increased opportunities in technology-related occupations and the importance of education and career guidance require that a discussion of possible changes to established programs be included in this examination of changing instructional issues.

Educational and Career Counseling in Elementary and Secondary Education

Career guidance for elementary school students more often than not takes the form of structured, periodic classroom sessions devoted to developing an awareness of career choices and options. On the secondary school level, educational experiences designed to increase a student's awareness of possible career choices are usually known as "career exploration programs. " School textbook publishers, and individual teachers, have developed materials that may be integrated into established curricula, or that guidance personnel may utilize in special programs designed to stimulate career interests.

As career choices in automated workplace environments increase, preparation for these careers may require that decisions relating to

*A large number of the members of the particular IBEW local studied worked on a temporary or permanent basis for small electrical contractors, many of whom could not afford to provide formal in-house training.

courses of study be made much earlier in a student's initial educational preparation. For example, a preliminary interest in technical or engineering careers may dictate an increased emphasis on a science and math—perhaps even in the elementary grades. In Japanese school systems, science and math education are stressed from the lower elementary grades and onward. In addition, science and math curricula are developed so that one level builds closely on the previous level.[58] It will be important that classroom materials used to stimulate career exploration reflect the likelihood of more frequent changes in careers, as well as the full spectrum of choices available. Given the relatively low participation rates of minorities and women in technical and engineering professions, exposure of minority and female children to career exploration materials will be especially important for future achievement of workplace equality. It will also help ensure that these children can make career decisions based on an examination of all possible choices.

On the secondary level, the goal of career guidance and counseling takes a different form. First, there is more often than not a centralized guidance function in the form of a guidance counselor or, in larger schools, a guidance department. For students who will enter the world of work directly after high school and for students who will go on to college or some other education or training experience, there are five career guidance needs:

- An awareness that career planning is vital . . .
- A broad awareness of alternatives . . .
- Knowledge of a process of decision making . . .
- Recent, easily accessible banks of information . . . and
- Systematic treatment with individualization.[59]

Leaders in the field of career guidance suggest that the work of school counselors will become more important as a result of increased use of advanced technologies in American society and the resulting need to encourage the personal growth required to deal with an increasingly complex and technical world.[60] In addition, information technology will play a greater role in the guidance process itself, as microcomputers, video disks, teletext and videotext serve as vehicles for delivery of career guidance systems to supplement the role of the counselor.[61] A variety of computer-based guidance systems are already used by high school guidance counselors. Many counselors who have used direct search and structured search systems—the two types of career databases currently available-have found them to be valuable resources.[62]

Career Guidance on the Postsecondary Level

Whether an individual enrolls in a degree program or simply takes selected courses, the focus of guidance programs in postsecondary institutions is usually more on placement than on examining career options. This focus has been in keeping with increasing enrollments in specialized, professional education programs. However, as technological and economic change forces individuals and institutions to think more in terms of broad-based occupational preparation rather than specialization, there will be a greater need for career guidance services on the postsecondary level. Barton points out that increases in adult enrollments and the growing need of adults for career counseling, based in part on technological and economic change, will present new challenges to the educational community:

> While there is increasing interest in adults among members of the counseling and guidance profession, that profession has mostly dealt with the young. There is quite a differ-

[58] National Science Board Commission on Precollege Education in Mathematics, Science and Technology, *Educating Americans for the 21st Century* (Washington, D. C.: National Science Board, September 1983).

[59] JoAnn Harris-Bowlsbey, "A Historical Perspective, " *Microcomputers and the School Counselor* (Alexandria, Va.: American School Counselor Association, 1983).

[60] Cynthia Johnson, "The Future, " *Microcomputers and the School Counselor (Alexandria, Va.: Amen"can School Counselors Association), 1983.*

[61] JoAnn Harris-Bowlsbey, op. cit., 1983.

[62] Laurence Shatkin, "The Electronic Counselor, " *Electronic Learning,* September 1983, pp. 75-77.

> ent set of issues involved in the problem of providing educational advisement and information to adults than there is in facilitating the movement of youth from high school to college. The colleges and universities have had almost a single source from which to get their students—the secondary school. Information about admissions and courses was funneled to students through high school counselors who were the linchpins between the high school and the college. And a standardized test, the Scholastic Aptitude Test (SAT)–at least from the college's standpoint–helped to grade and sort prospective students.
>
> . . . Potential adult students are not gathered in any central place. . . . They often have very specific objectives, and need to know what kind of education will enable them to reach these objectives, and where that education can be found in the community and at least cost in money and time. People who give good educational advice to adults have to know about the constraints working adults encounter. They must be briefed about employment and avenues of advancement, about what employers require, in order to relate an educational plan to an employment outcome. [63]

Other Sources of Career Counseling for Adults

A variety of organizations and institutions within the community now provide career counseling services to adults who are participants in the work force or who wish to enter or reenter the work force. In 1980, there were an estimated 7,991 commercial employment establishments operating in the United States. Some of them specialize in particular fields such as data processing or engineering, while others work with individuals interested in a broad range of career pursuits.[64]

Nonprofit organizations, such as community-based groups and churches, are becoming increasingly active, particularly in periods of high unemployment. National nonprofit organizations also have been formed to assist individuals in identifying job opportunities. For example, the National Center for Urban and Ethnic Affairs recently formed a national information clearinghouse for use by community groups across the country for self-help job counseling programs to aid the unemployed. The Center's clearinghouse staff now offer workshops to community leaders interested in establishing self-help job counseling centers.[65]

Other national nonprofit organizations are examining career opportunities for particular groups within the population. For example, Wider Opportunities for Women, Inc. (WOW), a Washington, D. C.-based organization that focuses on developing nontraditional career opportunities for women, is now sponsoring a Women's Work Force Project, to identify potential opportunities for women in high-technology industries.[66]

The Corporation for Technological Training, a nonprofit organization serving high-technology employers and individual job seekers in Montgomery County, Md., has created a Technical Occupations Employment Group that assesses industry skill requirements and provides testing, counseling, retraining, and placement assistance on an as-needed basis. Given the potential variances in skill mixes among high-technology and technology-intensive industries in different regions, such programs that focus on the needs of particular geographic areas or target populations may increase in numbers in the near-term future, provided there are available resources for their establishment and strong industry support.

As the need for educational counseling and career guidance increases because of expanded use of PA in manufacturing, advanced technologies in other types of work environments, and other factors, the need increases for current, reliable information on occupational trends and occupational preparation. This need for more efficient means of organizing and updating occupational information suggests the need for greater use of microcomput-

[63] Paul Barton, *Worklife Transitions* (Washington, D. C.: National Institute for Work and Learning, 1982).

[64] Data provided by the U.S. Department of Commerce.

[65] *NCUEA Building Blocks*, winter 1983.

[66] *Bridging the Skills Gap: Women and Jobs in a High Tech World* (Washington, D. C.: Wider Opportunities for Women, 1983).

ers and other technologies in the counseling process.[67]

Job Counseling, Outplacement, and Retraining for Displaced Workers

Many semiskilled and skilled workers who have lost their jobs in automobile, steel, and other heavy manufacturing industries, or who are on indefinite lay-off with slim prospects for ever returning to their former jobs, are looking for new jobs within the manufacturing or the service sector. In addition, due to both the increasing use of programmable automation and economic changes, the jobs of many currently employed semiskilled and skilled workers are at risk.

Unless these individuals are willing to take lower paying, lower skilled jobs, many will need to be retrained or to enhance their present skill levels so that they can compete for available skilled jobs. A few companies, unions, State universities, and community colleges now offer instructional programs designed with displaced workers in mind. A few universities and community colleges have begun to offer free courses to the unemployed in order to assist them in upgrading their skills.[68] However, other instructional programs are a "force fit. " Existing curricula and instructional methods may be inappropriate for the skill levels of displaced workers or for use with older adults. Often, too, skill levels of enrollees are not assessed initially, nor is place ment of enrollees after completion of training guaranteed.[69] As a result, participation rates are often low.

In the past, few retraining efforts for displaced workers have been sponsored by industry, for a variety of reasons, including: the lack of local alternative career opportunities, for which instruction could be provided; workers who resisted retraining in hopes that they would be called back to their old jobs; and the inability of companies closing plants to afford the cost of retraining displaced workers.[70] To date, most of the retraining programs established have been paid for with Federal funds. For example, the Trade Adjustment Assistance Program was the key funding source for the relocation programs of the 1970's. Special retraining projects for individuals affected by massive layoffs were funded through Department of Labor discretionary grants.[71] In recent years, State and local governments, through their economic development agencies, have begun to establish State training systems and skills *centers.* These centers aim to attract new industries to their geographic areas by providing them with a pretrained work force. They are often sources of training for displaced workers who meet entry eligibility requirements.[72]

The following factors complicate the process of providing retraining for displaced workers: 1) many have been out of school for a number of years and are uncomfortable with classrooms and instructional approaches designed for use with younger and less experienced students; 2) many have families and feel they cannot participate in education and training programs unless they also receive some form of stipend for living expenses or payment for work performed while engaged in on-the-job training; and 3) many need specialized job counseling and placement assistance in order to determine how best to utilize their present skills in preparing for new careers and in seeking out new employment opportunities.

Retraining programs established with the special needs of displaced workers in mind—programs in which their current skills and knowledge base are taken into account—are critical if the United States is to minimize the

[67] Harris-Bowlsbey, op. cit., 1983.
[68] "Free Courses Offer Jobless a 2d Chance, " *New York Times,* June 28, 1983.
[69] For a detailed account of one such program see "Retraining '83?" *Washington Post,* Nov. 6, 7, 8, and 9, 1983. The series describes a technician training program for former production line workers at General Motors' Southgate Plant in southern California.

[70] Jeanne P. Gordus, Paul Jarley, and Lewis Ferman, *Plant Closings and Economic Dislocation* (Kalamazoo, Mich.: W.E. Upjohn Institute for Employment Research, 1981).
[71] *Worker Adjustment to Plant Shutdowns and Mass Layoffs: An Analysis of Program Experience and Policy Options* (Washington, D. C.: National Alliance of Business, March 1983).
[72] Ibid.

problems of worker dislocation and increased use of PA on the manufacturing work force. Often, pretraining programs are required to address basic skills deficiencies or to reinforce basic skills, such as math, or to reinforce skills that have not been utilized in the jobs previously held by these workers.

Whether or not retraining is required for continued participation in the work force, the two types of services that most displaced workers need are job counseling or outplacement and retraining. These are discussed in more detail below.

Job Counseling/Outplacement

There are many similarities between the needs of displaced salaried workers for job counseling and placement assistance and the needs of displaced hourly production line workers. Both groups require assistance in assessing their marketable skills and in identifying job opportunities in which their skills may be utilized. If new skills need to be developed, both salaried and hourly workers need assistance in identifying appropriate sources of training and retraining. However, there is a marked difference in the ability of hourly workers to " . . . articulate value rather than need in representing themselves to prospective employers. "[73] For example, in responding to the question, "Why should I hire you?" the answer given by the former hourly employee will often be, "Because I need it to support my family," rather than "Because I have the following skills. " Organizations that have provided job counseling services to production line workers have noted that former hourly employees are frequently unable to project a positive image of themselves and tend to think of themselves only in terms of their previous jobs. Tom Jackson, whose consulting firm has worked with hourly employees displaced from the transportation, metalworking, electronics, petrochemical, and retail sales industries, describes the primary goal of job counseling and outplacement for these workers in this way:

> The fundamental issue here is to go beyond job title to the individual and the skills he or she possesses, as well as the qualities. Our job is to help the individual to reestablish his/her fundamental versatility and, through it, to adapt to change. The qualities that are unique to an individual are the forces that embody that person's ability to develop new skills. This is what we so often miss when we just look at the job a person has performed, rather than looking at the total person. Unfortunately, our educational institutions and many employers reinforce this limited view of the individual.[74]

Job Clubs and Seminars. -One of the most successful forms of job counseling and outplacement for former production line workers has been the job club, an organized group of unemployed workers who meet frequently to discuss and reinforce each other's job seeking

1ntewiew with Tom Jackson, chairman, The Career Development Team, Inc., March 1983,

"Interview with Tom Jackson, op. cit., March 1983.

Raymond O. was employed for 17 years as a Research Assistant with the Jones & Laughlin Steel Corp. in Pittsburgh, Pa. When he lost his job, he enrolled in the Robotics Installation and Repair Program developed especially for displaced steel workers by the Community College of Allegheny County, in close cooperation with the Westinghouse Corp., a producer of robotics equipment, Now Mr. O. attends classes 5 nights a week and works for a contractor during the day installing robots efforts. Job clubs are usually limited to 25 people or less. Sessions are devoted to job counseling and obtaining job leads, often with the help of professional counselors, and to practicing interviews. The other common type of job counseling for former hourly production personnel is job search seminars delivered by trained consultants." Goodyear Tire & Rubber Co., in conjunction with plant closings in Conshohocken, Pa., and Los Angeles in 1980, was the first U.S. firm to provide job counseling and outplacement to hourly production line workers, in addition to salaried administrative and supervisory personnel.[76] Six case studies of plant closings prepared for use in conjunction with a 2-day conference on plant closings sponsored by the Department of Labor in 1981 all stressed the importance of getting displaced workers actively involved in readjustment processes, including counseling and motivation sessions.[77]

Other Sources of Counseling and Placement Assistance.—The U.S. Employment Service, established under the Wagner-Peyser Act of 1933, has over 2,800 offices across the Nation. While the Employment Service offers all unemployed persons access to job listings and assistance in matching their skills to available job opportunities, the counseling and placement services it provides are extremely limited in scope. This is due partly to redefinitions over the years by the U.S. Department of Labor of the primary clientele for the Employment Service. For example, in 1965, the emphasis of the Employment Service was to be on working with the "employable' '-individuals who already possessed fairly marketable job skills, but who needed access to listings of available jobs. By 1971, however, the focus of Employment Service efforts was changed to working with those who were viewed by employers as "least employ able' '–individuals lacking basic math, reading, and language skills, and possessing physical or personal characteristics perceived as barriers to employability. With this shift in focus, most of the counseling provided by Employment Service personnel was received by those who were least "job-ready," or who had mental or emotional problems.'[a]

Given the changes in the designated audience for the Employment Service over the years since its creation, it is difficult to estimate how useful a tool it has been to displaced workers. Under the Trade Act of 1974, legislation designed to provide adjustment and relocation assistance to workers displaced as a direct result of foreign competition, the Employment Service is designated to administer employment services for the Trade Readjustment Assistance Program (TRA). For fiscal year 1981, the Department of Labor reported that of the 79,000 workers registered with the Employment Service under TRA, only 7,000 were placed in jobs as a result of Employment Service assistance.[79]

The Employment Service (called the Job Service in some States) has been designated to provide counseling and placement assistance to displaced workers under Title III of the newly enacted Job Training Partnership Act (JTPA). However, employers have been reticent over the years to list available job openings with the Employment Service/Job Service, partly because of the perception that, since its establishment, the agency has handled predominantly jobs with the lowest pay and the highest turnover.[80] These conditions, unless corrected, may influence how effective a role the Job Service can play in counseling and assisting displaced workers eligible for assistance under JTPA.[81]

CETA and Job Counseling/Outplacement. – Displaced workers were among the target groups eligible for assistance under Title II-C of the Comprehensive Employment and

"National Alliance of Business, op. cit., 1983.

[76]Tom Jackson, "Industrial Outplacement at Goodyear-Part 2: the Consultant's Viewpoint, " *The Personnel Administrator*, March 1980, pp. 45-48.

[77]*Plant Closings: What Can Be Learned From Best Practice* (Washington, D. C.: U.S. Department of Labor, 1982).

"Barton, op. cit., 1982.

"*Employment and Training Report of the President, 1983.*

[80]Barton, op. cit., 1982; testimony: U.S. Chamber of Commerce; National Alliance of Business, Committee for Economic Development in hearings before the Joint Economic Committee, Sept. 16, 23, 26, 1983.

"National Alliance of Business, March 1983.

Training Act (CETA). Under this section of the act, workers displaced through mass layoffs or plant closings were eligible for retraining, but only if they had received official notice of layoff within 6 months of their day of application and if the local CETA prime sponsor could certify that there was little or no opportunity for these workers to find employment in the same or an equivalent occupation within that geographic area. Given the complexity of the eligibility requirements, and also the 6.5-percent limit on retraining for those who did not meet standard income eligibility requirements, the infrequency of advance notice of plant closings, and the overall mission of CETA to serve the economically disadvantaged, few CETA prime sponsors used Title II-C moneys to retrain displaced workers.[82] In addition, while the intent of the CETA legislation was for counseling and placement assistance to be provided by local CETA offices or designated contractors, pressures on local CETA personnel to "train and place" resulted in little time for bona fide counseling and placement assistance.[83]

In summary, from available evidence, it appears that job search counseling and placement assistance have been effective tools in assisting displaced workers in improving their morale and self-image, and in developing adequate job search skills. The most effective sources of job counseling and outplacement services utilized to date with displaced workers have been job clubs and job search seminars delivered by trained consultants. However, in most instances, these services were delivered at the discretion of individual employers and have not been made widely available.

"Ibid.

[83]Barton, op. cit., 1982.

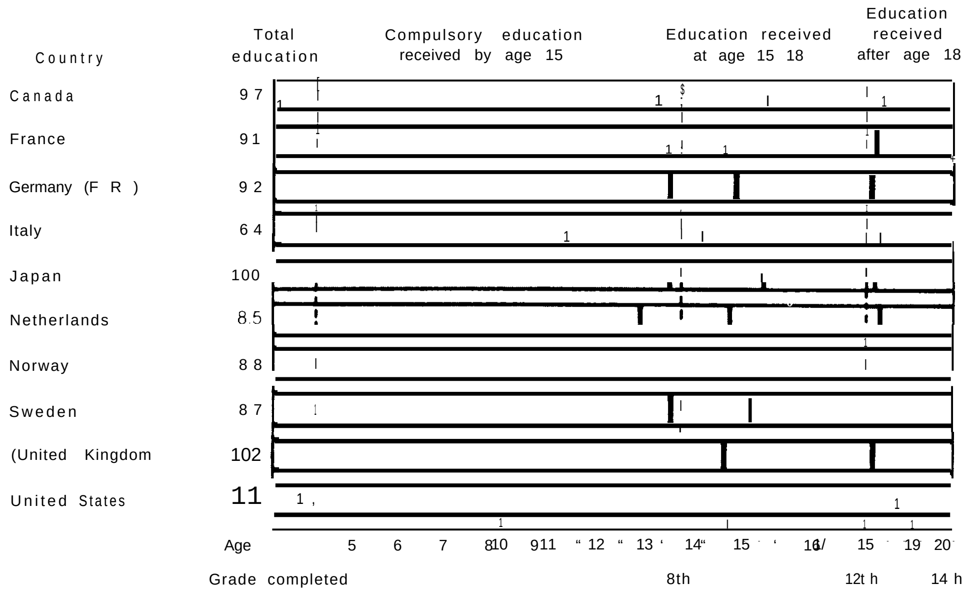
Education and Training in Europe and Japan

An education system in any country is a reflection of the values and traditions of the society it serves. As such, it is difficult to compare and contrast one national instructional system with another without making allowances for cultural and economic differences. Other distinctions in education systems, such as the ratio of public to private institutions, further complicate the process. Over the past year, a number of national studies have been critical of the U.S. education system and have identified attributes of instructional programs in Japan and Europe to be considered for adoption in this country. This section of the chapter will examine some of the similarities and differences between the United States, Europe, and Japan in approaches taken to instruction that serves as a foundation for PA-related skills development or that develops skills required in automated manufacturing.

Summary of Comparative Data

In the mid-1970's, the National Center for Education Statistics (NCES) reviewed and summarized findings from several studies that compared education in the United States with that of nine other countries: Canada, France, Germany, Italy, Japan, the Netherlands, Norway, Sweden, and the United Kingdom. NCES found that for the age group 25 to 64, the United States ranked first in adult educational attainment, with an average of 11.1 years of formal instruction. The United Kingdom was next highest, at 10.2 years of formal schooling, but closely followed by Japan, at 10.0 years (see fig. 21). By 1976, in all countries except Canada and the Netherlands, adult males aged 15 and over had slightly higher rates of educational attainment than females in the same age group. However, by 1980-81, the

Figure 21.—Comparison of Years of Formal Instruction Completed by Adults



SOURCE National Center for Education Statistics 1976

numbers of 18-year-old men and women in the Community of Ten* countries who were full-time students had increased by 36 percent for each sex.[84] NCES found education was a major government expenditure in all the nations examined, but Canadian expenditures represented the highest percentage of GNP (6.5), closely followed by the Netherlands (6.3 percent). U.S. expenditures in the year examined (1973) represented only 5.1 percent of GNP, while in Japan (for 1971), education-related expenditures amounted to only 3.0 percent of GNP (see fig. 22). During the the period 1960-70, the United States had less growth in higher education enrollments not attributable to population growth than any of the other countries studied. Immediately prior to the period examined, the United States had greater rates of higher education enrollment growth than any of the other nations (see table 54).

Vocational Training—A 1982 comparative study of vocational training systems in the Federal Republic of Germany, Austria, Korea, Taiwan, Spain, Holland, Japan, Liechtenstein, Great Britain, Ireland, Portugal, Switzerland, and the United States, found that vocational education is not highly regarded in these countries relative to its importance in producing skilled labor for continued industrial development. The vocational programs of the countries examined varied considerably in scope, enrollment levels, and available resources. For the most part, countries with long-established vocational training tended to consider apprenticeship as a broad-based foundation for lifelong, skills improvement. In contrast, nations that required rapid skills development in order to meet the needs of accelerated rates of industrial growth seemed to favor shorter term, specialized instruction delivered by vocational training schools or by industry personnel at manufacturing sites.[86]

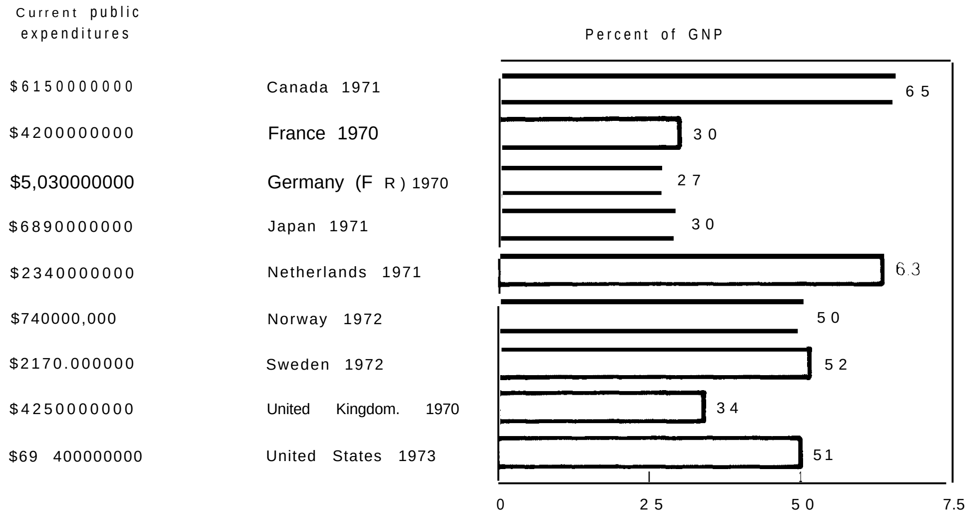
An important measure of the quality of initial vocational preparation (secondary level) is

*Federal Republic of Germany, France, Italy, The Netherlands, Belgium, Luxembourg, United Kingdom, Ireland, Denmark, and Sweden.

[84] "Education and Training," *Eurostat Statistical Bulletin*, Oct. 28, 1982.

[86] *"Comparison Among the Different Vocational Training Systems in the Countries Participating in the I. I?. W.,* International Organization for the Promotion of Vocational Training and the International Competitions of Vocational Training for Young People, July 1982.

Figure 22.—Comparison of Public Expenditures for Education



SOURCENationalCenterbrEducation Stat ist ic s 1976

Table 54.—Growth of Full-time Enrollment in Education, by Level in Selected Countries, 1960-70

	Annual average compound growth rate					
	In school-age population		In enrollment		In enrollment not attributable to population change	
Country	Secondary	Higher	Secondary	Higher	Secondary	Higher
Canada .	3.3	4.4	6.0	11,3	2.6	6.6
France	1.3	4.1	3.8	11.2	2.5	7.1
Germany (F, R.)	1.4	–2.1	3.3	7,3	1.9	9.6
Italy	–0.2	0.1	5.7	9.5	6,0	9.4
Japan	– 1.3	2.0	– 0.2	9.0	1,1	6.9
Netherlands.	0.4	3.4	2.8	7,8	2.4	4.3
Norway	0.9	4.2	NA	9.4[a]	NA	4,7
Sweden	– 1.3	3.4	3,5	NA	4,9	NA
United Kingdom	–0.1	2.4	1 ,2[a]	1 0.0[a]	1 .3a	7.4[a]
United States[b]	2.8	4.1	3.1	8.3	0.3	4.0

[a]Es t imated
b 195970

SOURCE Organization for Economic Cooperation and Development Paris, France *Education Statitisica Yearbook 1975 VOI* 1 sec II

the ability of those who have participated to demonstrate the mastery of skills. The International Skill Olympics, sponsored by the International Organization for the Promotion of Vocational Training, are designed to provide young people representing 14 member nations with opportunities to gain recognition for excellence in the skilled trades.

The United States has participated in six international competitions since 1973. As illustrated in figure 23, the United States has had the lowest average level of performance over the first five competitions, with a score as much as 24 points behind Korea and Japan and as much as 15 points behind Switzerland, Austria, Germany, and France. Although the

Figure 23.— Results of the International Skills Olympics

Average level of performance of national competlfors [n International competttlon since 1975

Country	Score
Austria	67.82
France	63.50
Germany	66.30
Japan	73.80
Korea	78.20
Liechtenstein	69.00
Switzerland	68.50
Taiwan	66.30
United States	53.60
Belgium	55.58
Ireland	57.20
Netherlands	61.70
Portugaf	53.80
Spain	60.80
United Kingdom	58.30

SOURCE: Harold Lewis, *Report on Participation in the International Skills Olympics* (Vocational Industrial Clubs of America, 1983).

United States ranked first in the auto mechanics competitions and third in the demonstration of electronics skills (see fig. 24), it held last place in the precision machining, welding, and construction trades. In assessing U. S. performance, an official of the Vocational Industrial Clubs of America, Inc. (VICA) has noted that the countries who placed highest in the International Skills Olympics include our toughest industrial competitors. VICA attributes the state of preapprenticeship trades skills in the United States, at least in part, to

> . . . an adversarial relationship that has developed between government, industry, labor and education regarding the production of a highly skilled, basic trades work force. "[86]

"Harold Lewis, *Report on Participation in the International Skill Olympics,* presented at the American Vocational Association Annual Conference, December 1983.

Figure 24.— Results of the International Skills Olympics

Electronics

Country	Score
Central European	69.65
United Kingdom and Other European	59.08
Asian	81.03
United States	68.50

SOURCE: Harold Lewis, *Report on Participation in the International Skills Olympics* (VICA, 1983)

Features of the Japanese Education and Training System With Relevance for Programmable Automation

This section highlights aspects of education and training systems in Japan that lay the groundwork for or develop skills directly related to programmable automation.

The Japanese education system is known throughout the world for its rigorous curriculum—particularly on the elementary and secondary levels. In a recent book on Japanese high schools, Thomas P. Rholen of the Center for Japanese Studies, University of California, estimated that as a result of an accelerated elementary and secondary curricula, " . . . the average Japanese high school student has the equivalent basic knowledge of the average American college graduate. " One in ten Japanese students do not finish high school, compared with one in four Americans.[87]

The Japanese education system was reformed after World War II. During this period, many new high schools, colleges, and universities were established and education through the junior high school level became mandatory for all citizens. This change in the mandatory education requirement and the broadening of access to instruction was a major contributor to Japanese industrialization.[88] Emphasis on science and math education begins in the early elementary grades. Three hours each week of math instruction in first grade is gradually increased to 6 hours each week in grades 4 through 6. Science education is provided by elementary school teachers who did not specialize in science but who have attended in-service training programs in govemment-established science education centers. While the goal of science education in elementary schools is to create a positive attitude toward science, curriculum is more structured on the junior and senior high levels. The Japanese Ministry of Education, under authority of the Science Education Promotion Law

"Thomas P. Rholen, *Japan High Schools* (University of California Press, 1983).

[88]"Y. Oshima, "Recent Trends of Manufacturing Technology in Japan, " *Automatic,* vol. 17, No. 3, May 1981, pp. 421-440.

of 1953, has established a program to improve elementary and secondary school science education—a program that includes grants to individual schools for the purchase of science equipment.[89]

Japanese students who goon to high school enter one of a number of programs: general, engineering, agriculture, or commerce.[90] Examinations are required for high school entrance and the scores received on these exams determine each individual's occupational and social status. Vocational schools are available to students who do not achieve high ranking on high school entrance exams. The entire high school curriculum is geared to preparing students for highly competitive, college and university entrance examinations.[91]

Shortages of technical and engineering instructors on the junior college, college and university levels have resulted in few robotics course offerings in Japan. In addition, some universities do not consider robotics an appropriate topic for inclusion in engineering curricula. As a result, engineering graduates often require additional instruction before they are prepared to work in automated manufacturing facilities. However, some educational institutions that are not under the jurisdiction of the Japanese Ministry of Education are beginning to offer robotics programs in response to the needs of Japanese industry.[92]

Japanese manufacturers now operate a few engineering schools of their own. These institutions offer programs in robotics operation and maintenance, as well as industrial engineering programs that include robotics instruction.[93] In Japan, industry assumes responsibility for training and retraining its employees. Within firms where "lifetime employment" is the official policy, industry-provided instruction is a necessity, since the majority of new employees recruited have just completed their formal education.[94] The amount and type of training and retraining received by an individual is highly dependent on the stage of the worker's career and, to a lesser extent, on expected tenure. Training for entry-level and young workers is more extensive and formal than instruction for older employees, although experienced workers automatically receive formal training upon promotion.[95]

A study conducted by the Japanese Ministry of Labor on the impact on employment of robotics and NC equipment *in* 10,000 Japanese manufacturing facilities found that over 60 percent of the companies had initiated specialized training programs in conjunction with adoption of these technologies.[96] However, shortages of technical instructors are an impediment to the establishment of PA-related training in many Japanese firms, just as they are for U.S. companies. Producers of PA equipment and systems provide some training, but there is no information available on its nature or content. As is the case in the United States, small manufacturing firms do not have the time or the resources to provide PA-related instruction to employees.[97]

Training Offered by a Japanese Firm in the United States.–Training programs offered by Nissan Motor Manufacturing Corp. U.S.A. are representative of employee education and training provided by the Nissan Corp. in Japan. Nissan U. S.A. 'S truck manufacturing facility in Smyrna, Term., is one of the most automated of Nissan's plants, with 219 robots and other forms of automated equipment and systems in use in body assembly, stamping, and painting operations; and a "just-in-time" parts delivery system.

The training system adopted at Nissan U.S.A. is one manifestation of the distinctive

[89] "*U.S. Science and Engineering Education and Manpower: Background; Supply and Demand; and Comparison With Japan, the Soviet Union and West Germany*, report prepared by the Congressional Research Service for the Subcommittee on Science, Research and Technology, House Committee on Science and Technology, April 1983.

[90] Souji Inagaki, *Education and Training: Comment From Japan*, paper presented at the 13th ISIR/Robot 7.

[91] Rholen, op. cit., 1983.

[92] Inagaki, op. cit., 1983.

[93] Inagaki, op. cit., 1983.

[94] Paul H. &On, *The Robot Scene in Japan: An Update (New* York: Daiwa Securities America, Inc., Sept. 7, 1983).

[95] James A. Orr, et al., *U.S.-Japan Comparative Study of Employment Adjustment* (Washington, D. C.: U.S. Department of Labor-Japan Ministry of Labor, November 1982).

[96] Aron, op. cit., 1983.

[97] Inagaki, op. cit., 1983.

approach being taken to plant management. In keeping with a streamlined, five-level management structure, an interest in encouraging employee participation in plant decisionmaking and the need to move employees to different stations in the facility to improve productivity, Nissan U.S.A. has developed special maintenance technician, manufacturing technician, and supervisor training programs for its personnel. Technician training is designed to develop multiple skills and produce an employee who can perform a number of different jobs and work effectively as a member of a team. Instructors are Nissan personnel, professors from nearby universities, or training consultants. Some of the supervisory personnel were sent to Japan for instruction lasting from 1 to 4 months that took place in selected Nissan plants prior to the opening of the Smyrna facility in 1983. Production line personnel who are not technicians or supervisors receive a minimum of 21 hours of general instruction, then as much as 20 hours of job-specific training, such as body assembly.*

*Note that the Japanese use the term "technician" relatively broadly, applying it to individuals designated production workers by Americans.

Nissan U.S.A. has opened a 30,000 square foot, onsite training facility that contains classrooms and a shop area that has demonstration models of all robots in use in the plant, a paint booth and a maintenance area.[98] Figures 25, 26, and 27 illustrate the training processes for these training programs, from employee selection for preemployment training through certification. Instruction offered at the Smyrna plant may be a reflection of the more extensive use of programmable automation by Japanese firms to date, or it may simply be a reflection of a different approach to training for production line personnel than that taken by American companies.

"''Nissan Trains U.S. Workers in Japan, " *Automotive News*, May 31, 1982; address by Marvin T. Runyon, President and Chief Executive Officer, Nissan Motor Manufacturing Corp. U.S.A. before the Foreign Correspondents Club of Japan, Tokyo, Japan, Mar. 29, 1983; material provided by Larry P. Seltz, Director, Personnel Development, Nissan U. S. A.; "Stringent Screening, Training by Nissan, " *American Metal Market Metalworking News*, June 6, 1983.

Assessment: Capacity of the U.S. Instructional System to Meet the Challenge Posed by Programmable Automation

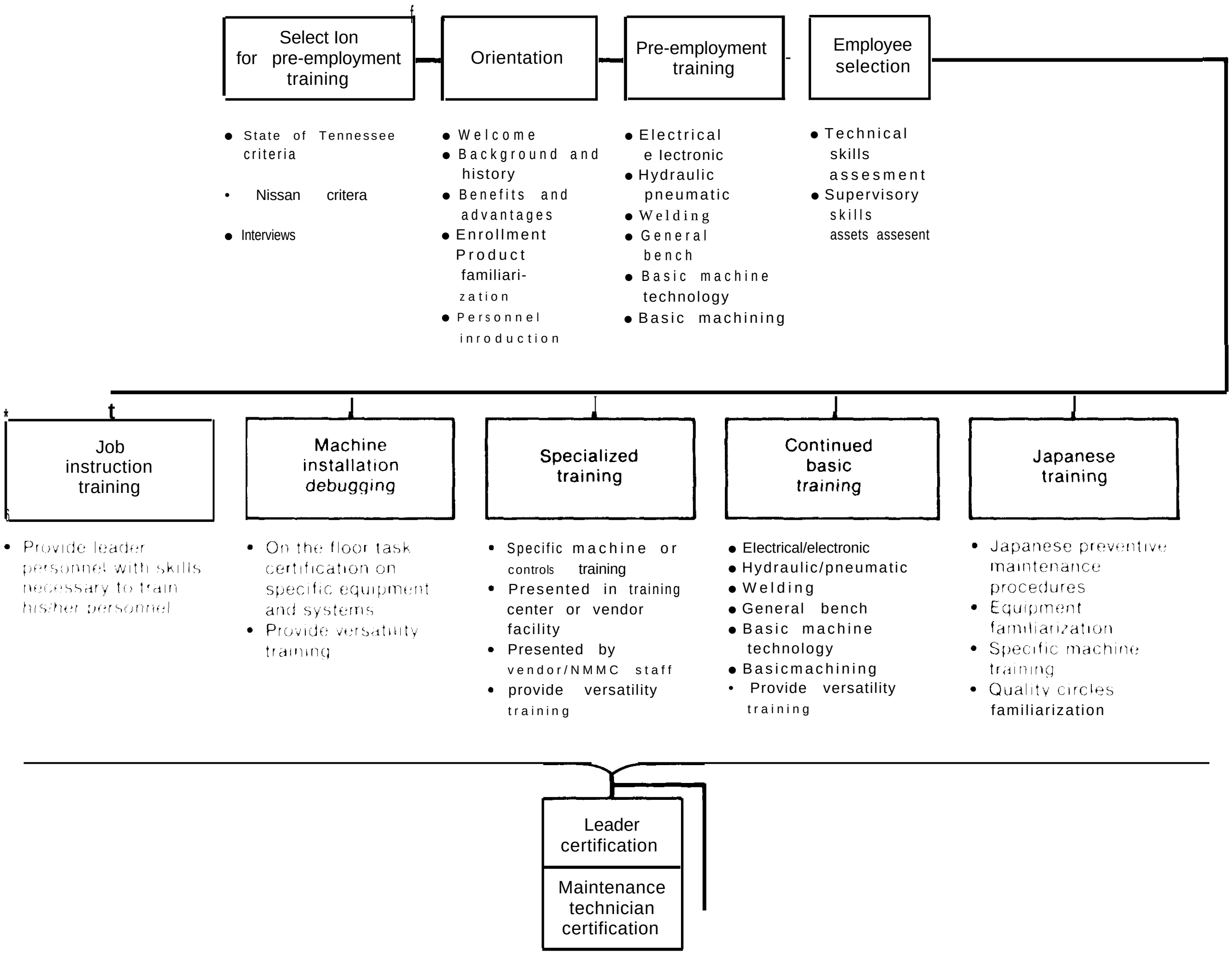
Current Instructional Capacity

There is little information on the number of educational institutions with course offerings or full-blown curricula for programmable automation, with the exception of robotics and computer graphics. Robotics International, an affiliate group of the Society for Manufacturing Engineers, conducted a survey of over 2,000 trade and technical schools, community colleges, and universities to identify robotics training and education activities in North America. Findings indicated that, in the summer of 1982, there were 27 institutions that listed robotics degrees or options among their programs and 74 more that offered robotics courses.[gg] Table 55 *is* a listing of the responding institutions categorized by type of program and, within types, by kind of institution. The amount of educational activity related to robotics probably reflects the large amount of attention this form of PA has received over the past few years more than it does the degree of sophistication currently found in robotics curricula.

Computer Graphics World, a monthly, commercial journal that tracks advances in computer graphics software and applications, con-

'*Directory of North American Robotics Education and Training Institutions*, Robotics International, 1983.

Figure 25.—Maintenance Technician Training at Nissan U.S.A.



SOURCE Nissan Motor Manufacturing Corporation Corporation U.S.A

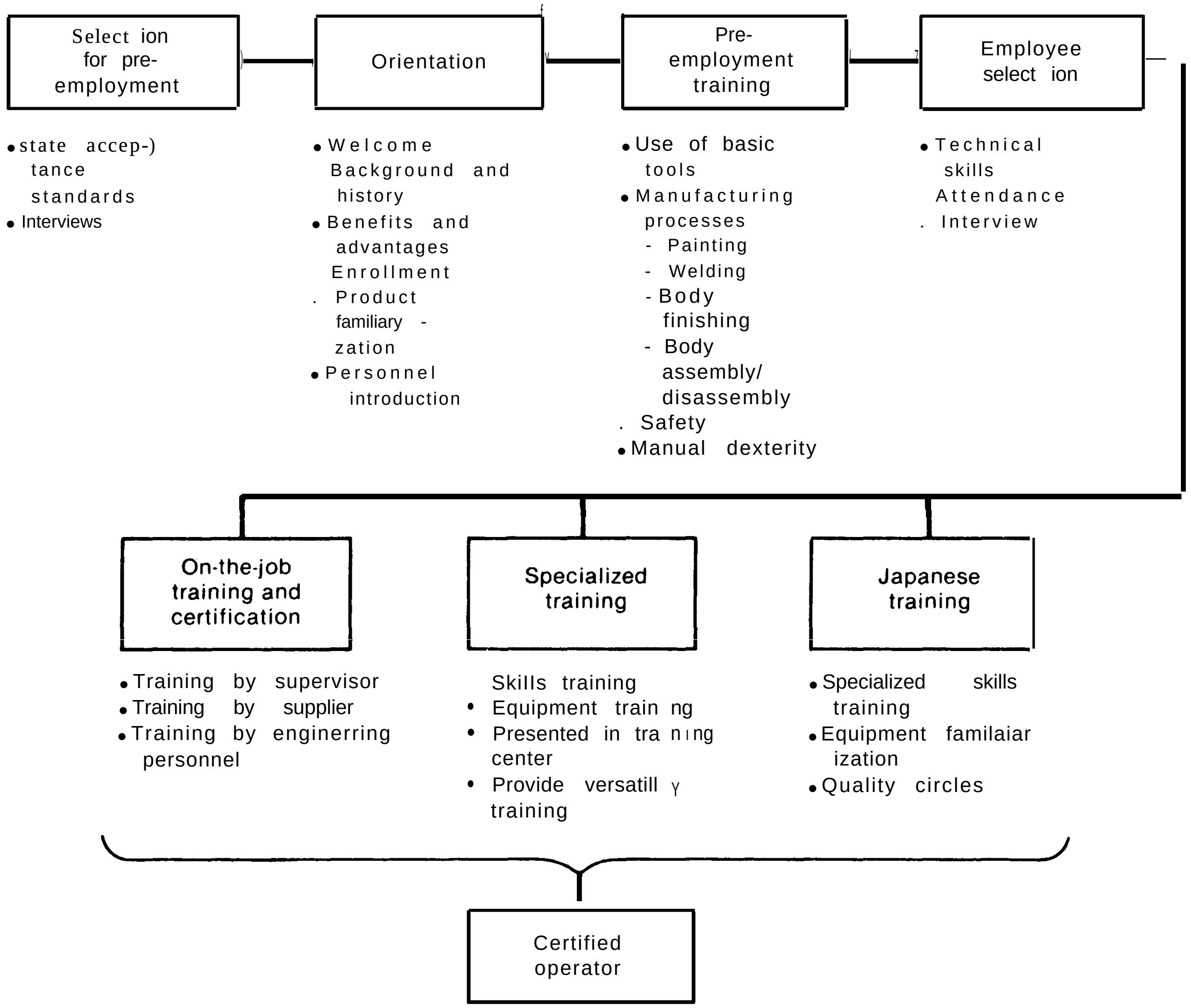
ducted a survey in 1983 designed to identify universities that offer the following types of computer graphics instruction:

- Computer graphics research,
- animation,
- CAD and CAM,
- computer-aided instruction,
- design/architecture,
- design/graphic arts,
- land resource,
- medicine, and
- other.

Results of the survey indicate that 84 universities in the United States and five universities in Canada provide one or more types of computer graphics instruction in their engineering, drafting, computer science, or art programs. However, the survey did not evaluate the relative quality of these programs.[100]

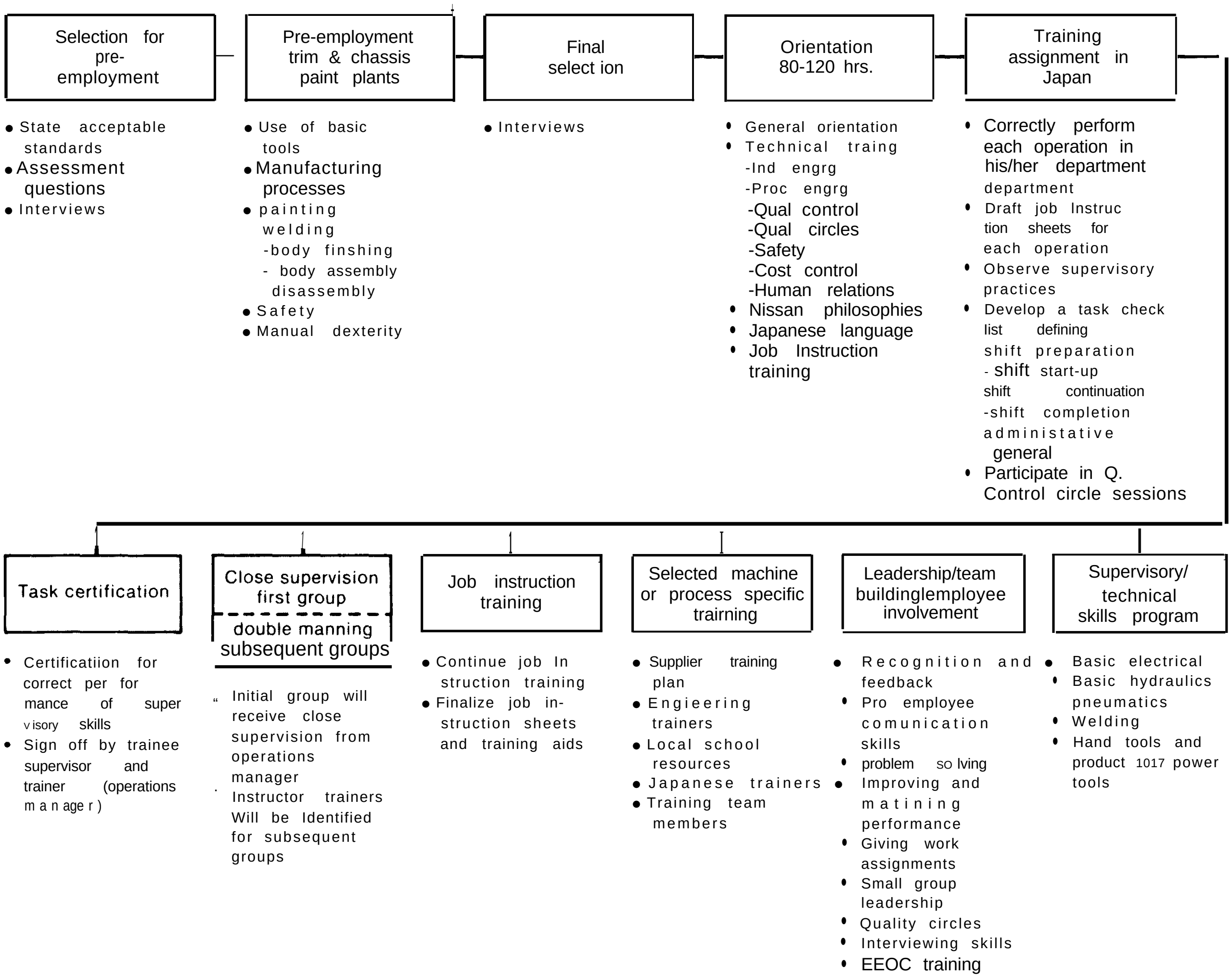
[100] "Survey of University Computer Graphics Instruction," *Computer Graphics World, vol. 7, No.*1, January 1984, pp. 54, 56, 58.

Figure 26.—Manufacturing Technician Training at Nissan U.S.A.



SOURCE Nissan Motor Manufacturing Corporation U S A

Figure 27.— Manufacturing Supervisor Training at Nissan U.S.A.



SOURCE: Nissan Motor Manufacturing Corporation U.S.A.

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Table 55.—Robotics Degree Programs and Course Offerings in North America, 1982

State	Number
I. Robotics degrees and/or options in robotics as part of an engineering degree	
2-year schools	
Colorado	1
Florida	2
Illinois	1
Michigan	6
Ohio	1
South Carolina	1
4-year schools	
Florida	2
Michigan	1
New York	1
North Carolina	1
Oregon	1
Pennsylvania	1
South Carolina	1
Graduate-level schools	
Georgia	1
Illinios	1
New York	1
North Carolina	1
Pennsylvania	2
Texas	1
II. Robotics courses	
2-year schools	
Alabama	1
Arizona	1
Florida	1
Georgia	
Illinois	;
Indiana	1
Iowa	1
Maryland	
Michigan	;
North Dakota	1
Ohio	3
Tennessee	1
Wisconsin	2
4-year schools	
Arizona	1
Arkansas	1
California	4
Colorado	1
Delaware	1
District of Columbia	1
Florida	1
Georgia	1
Illinois	2
Indiana	2
Michigan	5
Misssissippi	1
Missouri	1
Nebraska	1
New Jersey	1
New York	2
North Carolina	1
Ohio	2
Pennsylvania	1
South Carolina	1
Tennessee	1
Texas	1
West Virginia	1
Wisconsin	1
Graduate-level schools	
California	1
Delaware	1
Florida	2
Illinois	1
Indiana	1
Michigan	2
Missouri	1
New Jersey	1
New York	1
North Carolina	1
Ohio	1
South Carolina	1
Tennessee	1
Texas	2
Wisconsin	1
Canada	1
III. "Support courses" generally part of a robotics degree program	
2-year schools	
Alabama	2
Arizona	1
California	3
Colorado	2
Connecticut	1
Florida	1
Georgia	1
Illinois	6
Indiana	1
Iowa	4
Massachusetts	
Michigan	;
Mississippi	1
Missouri	1
Nebraska	2
New Jersey	1
New York	3
North Carolina	6
Ohio	7
Oklahoma	2
Oregon	3
Pennsylvania	3
South Carolina	3
Tennessee	1
Texas	6
Virginia	1
Washington	3
Wisconsin	7
4-year schools	
California	1
Illinois	1
Indiana	1
Louisiana	1
Massachusetts	1
Michigan	1
Mississippi	1
New York	3
North Dakota	1
Ohio	3
Texas	1
Canada	1
Graduate-level schools	
California	1
Hawaii	1
Nevada	1
Ohio	1
Texas	1
Utah	1

SOURCE: Robotics International, *Directory of North American Robotics Education and Training Institutions*

s noted earlier in this chapter, the instructional requirements for programmable automation are still emerging. **But even based on current skill requirements for automated manufacturing facilities, widespread use of programmable automation would pose challenges** (in the form of increased demand for the development of certain skills) to elementary, secondary, postsecondary, and continuing education. Industry-based and labor union-based instructional programs will also be affected by the increased need for technical instruction.

The present capacities of the U.S. instructional system to prepare students for employment in computer-automated manufacturing facilities and other types of work environments are limited by shortages of equipment, inadequate facilities relative to present and potential future demand, and inadequate supply of quality instructors for technical and engineering education. In addition, shortages of science and math instructors on the elementary, secondary, and postsecondary level complicate the process of developing adequate basic skills in individuals who may wish to prepare themselves for careers in automated manufacturing. Shortages of state-of-the-art equipment and of technical instructors are also problems faced in industry-sponsored, in-plant instructional programs.

Based on OTA research, it is questionable whether the capacity represented by the U.S. education, training, and retraining system will be sufficient to meet the challenge of widespread use of programmable automation, should extensive adoption of programmable automation occur. Instructional institutions are willing and interested in meeting the challenge, but it is unlikely that they will be able to do so unless equipment and instructor shortages are resolved. In addition, unless stronger links are developed between industry, labor, educators, and government, it is questionable whether programs now in development and those that will be designed in the future will be in keeping with present and anticipated PA-related skills requirements. Intersector cooperation is also needed to ensure that labor market information is widely disseminated among all those affected by programmable automation: i.e., individuals preparing to enter the work force; institutions that provide education and career counseling services; employers who need the information for long-range planning; and labor unions, who require it to advise their members of the need to retrain or otherwise enhance skills.