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ABSTRACT

In view of the rapid change in computer-related technologies and their societal applications, one would expect diverse opinions among educators about the need for computer literacy in schools and the best methods of attaining it. In addition, the definition of computer literacy has continually changed along with changing technological applications in various sectors of society. Indicators of the integration of computer-related tools, methods, and concepts into the curricula of vocational education programs are found in state and local education agencies' policies, curriculum guidelines, topics at vocational education conferences, teacher training, textbooks, and software developments. Because of the current information revolution and the lack of appropriate mechanisms for vocational education to anticipate change, the rapid technology change makes predictions concerning skills requirements uncertain. Views regarding the impact of automation on employment include the less-skill perspective, the more-skill perspective, and the view that society is in a period of transformation or paradigm shift. Vocational education needs to find methods not only to respond to the changing workplace but to anticipate changes in it. (Appendixes include a study of computer literacy requirements in three sample occupations and a study of vocational instructors in computer specialist occupations.) (YLB)

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Computer Literacy in Vocational Education: Perspectives and Directions

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STATE-OF-THE-ART PAPERS

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The University of Tennessee College of Education

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Computer Literacy in Vocational Education: Perspectives and Directions

by

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FOREWORD

The Office for Research in High Technology Education at the University of Tennessee, Knoxville, is conducting a program of work on high technology and its implications for education. Funded by the U.S. Department of Education's Office of Vocational and Adult Education, the program addresses the skill requirements and social implications of a technology-oriented society. Issues concerning computer literacy and computer applications are a focus of the program. The balance between the liberal arts and technological skills and the complementary roles they play in enabling people to function in and derive satisfaction from today's high-technology era are also addressed. The program's efforts are targeted at secondary schools, two-year post-secondary institutions, community colleges, universities, industrial training personnel, and other education and training groups.

The program consists of three major components:

At Home In the Office Study - At Home In the Office is an experiment that has placed office workers and equipment in the workers' homes to determine (1) what types of office work can effectively be done at home and (2) the advantages and disadvantages of home work stations. The implications for educators, employers, and employees will be significant, as work at home offers a possible avenue of employment for people living in rural areas, parents of pre-school children, handicapped individuals, and others.

COMTASK Database - COMTASK is a model of a computerized task inventory for high-technology occupations. The outcomes of the COMTASK system include a sampling of task analyses, the demonstration of how these task analyses can be rapidly updated, a manual for conducting task analyses to provide data for the system, and a guide to using the system.

State-of-the-Art Papers - A series of nine papers is being developed to address high technology and economic issues that are of major concern to education. Nine working titles have been selected:

- The Changing Business Environment: Implications for Vocational Curricula
- Computer Literacy in Vocational Education: Perspectives and Directions
- Computer Software for Vocational Education: Development and Evaluation
- Educating for the Future: The Effects of Some Recent Legislation on Secondary Vocational Education
- The Electronic Cottage
- High Technology in Rural Settings
- (Re)Training Adults for New Office and Business Technologies
- Robots, Jobs, and Education
- Work in a World of High Technology: Problems and Prospects for Disadvantaged Workers

Abstract

This paper examines four questions:

1. What is computer literacy?

2. How important is computer literacy in preparing students for the workplaces of the information society?

3. What computer-related skills and knowledge are or will be needed?

4. What needs to be done to make vocational education programs more responsive to students' needs for computer literacy?

The paper's findings reflect a central issue: the pace of change in today's information-based society, and the lack of appropriate mechanisms for vocational education to anticipate change. Not only must vocational education programs and institutions adapt and be flexible; in addition, students must learn the higher level concepts and problem-solving skills they need for continued learning as job environments, functions, and requirements change.

Traditionally, computer-related skills and knowledge have been taught in separate courses for computer-specialist careers such as data entry and computer operations. Now, computer-related skills and tools must be integrated into all areas of the vocational education curriculum, both to prepare students for the workplace and to improve their productivity as they learn.

About the Authors

Beverly Hunter, who was primarily responsible for the material in the text and Appendix A, has, since 1965, conducted and directed research, development, and dissemination activities to advance the state of the art in educational computing, computer literacy, and computer-based instruction. She has authored or coauthored numerous books, articles, and technical reports for government, business, industry, and academic institutions. Her recent book, My Students Use Computers, is providing curriculum guidance to school teachers and administrators throughout the United States. She is also the principal author of Learning Alternatives in the U.S. Education: Where Student and Computer Meet. She chaired the recent task force on computer literacy of the U.S. Department of Education's Office of Evaluation and Testing.

Robert Aiken, who contributed the material in Appendix B, served with Beverly Hunter on the computer literacy task force and has been a leader in the Association for Computing Machinery as Chairman of its computer science education interest group, representative to the Commission on Software Issues, and member of the ACM Education Board. He is a coauthor of the computer literacy text, Computer Power.

About the Editors

This paper has been prepared as part of a series of state-of-the-art papers edited by Lillian A. Clinard, an associate director of The University of Tennessee's Energy, Environment, and Resources Center (EERC), and Mary R. English, a research associate at EERC. The editors, who have been on assignment to the Office for Research in High Technology Education, were responsible for selecting the series' authors, reviewing and coordinating external reviews of the papers, and preparing the papers for release.

Acknowledgments

The editors extend thanks to Michael Moshelle and John Peterson, who reviewed earlier drafts of this paper, and to the U.S. Department of Education's Office of Vocational and Adult Education, which also provided a review.

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INTRODUCTION

By now, there is no doubt that computers and related technologies have had, and will continue to have, farreaching effects on U.S. and world economic and employment patterns. Views in the scholarly literature and popular press differ about the nature and extent of these effects. Despite a rapidly changing present and an increasingly uncertain future, however, vocational educators must provide their students with the opportunity to acquire the skills, knowledge, and attitudes needed in order to survive and thrive in what is often called the "information society." Because of the central, highly visible roles of computers and related technologies in the post-industrial world, considerable attention currently is being paid to the concept of "computer literacy" in preparing students for work and citizenship.

Purpose

This paper's purpose is to help educators, industry leaders, and government officials concerned with vocational education to identify needs and directions for computer literacy in vocational education. The paper addresses the following questions:

- What is computer literacy?
- How important is computer literacy in preparing students for the workplaces of the information society?
- What computer-related skills and knowledge are or will be needed?
- What needs to be done to make vocational education programs more responsive to students' needs for computer literacy?

Approach

Initially, this study was based on the straightforward assumption that computer literacy needs in vocational education could be derived from systematic analyses of the tasks performed in the occupations addressed by vocational education programs. In the classical approach to instructional systems development, one analyzes the job tasks, determines the skills and knowledge needed, and then translates these skill and knowledge requirements into instructional objectives.

As planned, this study's methodology entailed the following four steps:

- Select a sample of occupational areas.[6] (Secretarial work, bookkeeping, and drafting were selected.)
- Gather all available job/task inventories for these areas.
- Extract from these inventories all computer-related tasks; then analyze them to determine their computer-related skill and knowledge requirements.
- Compare these requirements with existing vocational education curricula in the sample occupational areas, to identify aspects of the curricula that need revision or improvement.

This methodology was unsuccessful because available job/task inventories in the sample occupational areas do not reflect computer-related tasks and computer-based methods known to be prevalent in these occupations. It became apparent that the current procedures for developing and disseminating job/task inventories are inadequate to handle the rapid technological change going on in America's workplaces.

A revised approach to the study was to take a broader look at the impact of technological change on the U.S. economy and its occupational structures, and then to take a more long-range look at the implications of

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these changes for computer literacy requirements in vocational education. The paper's text is directed toward this revised approach, and a summary of its findings and recommendations is given below.

The initial approach, although methodologically unsuccessful, proved useful as a backdrop to the broader overview and derived some valuable information and insights. The initial approach and its findings are thus summarized in Appendix A. In addition, a corollary study was done of vocational instructors in computer specialist occupations (i.e., in such fields as data entry and computer operations which focus on computers rather than simply using them), since historically and at present, much of the computer-related instruction in vocational education has been in these occupations. Appendix B summarizes that study.

Findings and Recommendations

The most pervasive problem vis à vis computer literacy and vocational education is the pace of technological change in the workplace and the inability of traditional vocational education mechanisms and institutions to be proactive with respect to that change. That is, vocational education curricula tend to be out-of-date because they reflect past workplace requirements rather than envisioned future requirements.

A major reason for this obsolescence is that schools do not budget for change in their vocational education curricula. Vocational education institutions, both secondary and postsecondary, spend relatively miniscule proportions of their budgets on program development and improvement. Of their budgets, nearly all goes for maintenance of existing programs.

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According to a 1979-80 survey, 74 percent of the secondary-level vocational education institutions spent nothing on new programs, and 90 percent spent less than 5 percent of their budgets for new services (Vocational Education Study Publication No. 8, 1981).

The following summary of this report's findings and recommendations all reflect this central issue.

Changing definitions of computer literacy. In the U.S. educational community as a whole, the concept and definition of "computer literacy" has evolved and changed over the past fifteen years. These changes reflect new computer technologies, the increased availability of computers in schools, and new ways in which computers are used in various endeavors. For the foreseeable future, computer literacy requirements will continue to change, and this should be taken into account in curriculum development, teacher training, equipment acquisition, and the like.

Differing visions of future skill requirements. Economists and futurists disagree in their predictions about the impacts of automation on the skills needed by workers. Some predict an overall lowering of skill requirements as a result of automation, while others argue that an expanding economy in an increasingly automated work environment will require greatly increased levels of education and higher levels of skill and knowledge on the part of the workforce.

Agreement that computer literacy is one of the major "basics" of education. Despite these changing definitions and differing perspectives, nearly every recent educational study group and commission has recommended that computer literacy be included as one of the "basics" in a core

educational curriculum, and that increased emphasis be placed on higher level cognitive and social skills in problem-solving and information-handling.

Relative emphasis on emerging versus traditional occupations. Current vocational education literature and the popular press indicate considerable interest in and concern about developing vocational programs for "emerging" high-technology occupations such as robotics technicians and telecommunications specialists. However, in terms of the numbers of students and workers affected, changes in the more traditional occupations, such as secretarial or accounting clerk jobs, are far more important. Curricula in these basic, traditional vocational areas should be periodically reassessed for their computer literacy needs.

More emphasis on higher level skills. With computers taking over more and more of the rote, repetitive tasks once performed by clerical and other workers, curricula need to place more emphasis on the so-called higher level skills such as applying principles and concepts, problem-solving, and decisionmaking. For example, the increasing use of personal computers for accounting and bookkeeping in small as well as large organizations suggests that students should learn accounting and bookkeeping principles, methods, and procedures using these computer-based tools. Since the computer programs perform the time-consuming and repetitive chores of calculation and data-posting, students can spend proportionately more time focusing on principles and on analytical and decisionmaking functions.

Learning to learn. New information-handling equipment and methods will continue to be introduced in workplaces. Students need to develop

confidence in their abilities to learn new concepts and use new tools and techniques. For example, secretaries with word-processing skills need to be able to learn to use computer-based work stations that combine word-processing functions with communication and data-processing functions.

Productivity tools for learners. A proficient use of computer-based tools (e.g., computer-aided drafting and design tools) depends upon many of the skills and concepts taught in conventional courses. However, it is likely that students could learn these prerequisites more efficiently and effectively with the aid of computer-based tools such as database managers, word-processors, graphing tools, and so forth.

Adequacy of the existing software base. The wide variety of application software packages currently available for use with personal computers — e.g., word processors, database managers, graphics, electronic spreadsheets, and accounting packages -- provide valuable sources of learning materials for such vocational education courses as typing, office methods, bookkeeping and accounting, drafting, business mathematics, and many others. The lack of appropriate software is no longer an obstacle to integrating computer literacy into vocational education curricula.

The need for current job/task information. One of the most serious problems confronting vocational educators is a lack of systematic and comprehensive information on the computer-related tasks that will soon be performed by workers in increasingly automated offices, farms, and factories. As mentioned earlier, the methods and procedures used to develop and disseminate job/task inventories are inadequate to keep up with the pace of change. Lacking a systematic and accurate basis for

reassessing curricula, vocational educators run the risk of investing important amounts of time and money in developing curricula and operating programs which teach obsolete or low-priority skills and knowledge.

The need for a focus on cognitive skills and knowledge in job/task information. The current approaches to analyzing and cataloging job tasks are completely behavioral (e.g., "manipulate keys, levers, and switches"). To gain more insight into the computer-related skills and knowledge needed in many job situations, job/task analyses should focus more on the cognitive aspects of tasks, such as problem-solving, decisionmaking, and troubleshooting.

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WHAT IS COMPUTER LITERACY?

In view of the rapid change in computer-related technologies and their societal applications, one would expect diverse opinions among educators about the need for computer literacy in schools and the best methods of attaining it. In addition, the particular skills, knowledge, attitudes, and understanding which define "computer literacy" have continually changed along with changing technological applications in various sectors of society.

However, although there have always been diverse views about the appropriate definition and scope of "computer literacy," the predominant opinion has tended to progress in three overlapping stages. In general, definitions of computer literacy have moved from

- knowing <u>about</u> computers, to
- <u>using</u> computers in various disciplines, to
- <u>reassessing</u> the fundamentals in basic disciplines as a result of the impact of computers on the methods and content of the disciplines themselves.

Views in the 1970s

During the 1970s, there were several major national and regional study groups who addressed computer literacy requirements in K-12 education. Vocational education was not often addressed in these studies, and it appears that vocational educators were not actively involved in such study groups.

In 1972, the Conference Board of Mathematical Sciences Committee on School Education prepared their <u>Recommendations Regarding Computers in High</u>

School Education. They recommended

> . . . the preparation of a junior high school course in "computer literacy" designed to provide students with enough information about the nature of a computer so that they can understand the roles which computers play in our society.
>
> . . . introduction to computing, as a follow-up to the computer literacy course.
>
> . . . integrate computing into high school mathematics courses and . . . in the early study of courses outside mathematics.
>
> . . . a major effort aimed at making vocational computer training more generally available and at the same time improving the quality of such training. (pp. 1-2)

Also in the early 1970s, the Human Resources Research Organization undertook a study funded by the National Science Foundation to examine national models and strategies for developing and disseminating computer-related curricular materials (Hunter, Kastner, Rubin, & Seidel, 1975). Among this study's conclusions was the following:

> Computing literacy. Assuming continued growth of computing in society in general, and continually increasing influence of computer-based systems and methods in most scientific, business and technological jobs, then a need seems obvious to enable citizens to gain knowledge of computer systems. Insofar as educational curricula are intended to provide students with job-relevant skills, then curricular materials and learning objectives relevant to these skills would be in demand as part of the curriculum at all levels of education.
>
> If the trend toward increased dependence on computing systems in society is assumed to continue, one can foresee the time in a decade or two when computing literacy would be as universally required as the ability to read and write. (p. 320)

In 1977, with support from the National Science Foundation, the Minnesota Educational Computing Consortium developed a set of objectives for universal computer literacy. The objectives were targeted at

junior-high-school students and emphasized knowledge about computers and their impacts on society as well as skills in using computers (Johnson, Anderson, Hansen, & Klassen, 1978). These objectives were widely used in school districts throughout the country to define their computer literacy curricula.

A similar but much broader and more comprehensive set of computer literacy objectives was developed in the late 1970s by the Oregon districts of Clackamas, Multnomah, and Washington (Oregon Tri-county Goal Development Project, 1979). This set of over 500 course goals in computer education remains unique among such studies in its strong emphasis on the cognitive processes of inquiry and problem-solving. Its sensitivity to the effects of computers on society and values is probably even more relevant today than it was in 1979.

Developments in the 1980s

The advent of low-cost microcomputers in the late 1970s spurred, among parents, teachers, and students, a surge of interest in computer literacy. Government agencies increasingly were pressed to support a variety of projects, programs, and policies related to educational computing and computer literacy. By 1980 there were diverse interest groups with emphatic and often competing demands about computer literacy.

In December, 1980, a select group representing a spectrum of constituencies in education and computing research was convened in Reston, Virginia, to address the topic "National Computer Literacy Goals for 1985" (Seidel, Anderson, & Hunter, 1982). The main purpose of this effort,

sponsored by the National Science Foundation, was to air opposing views on computer literacy and to move toward greater consensus on national needs and goals. The range of views on what, exactly, computer literacy is was testimony that different people, depending on their interests and societal roles, need different computer skills and knowledge. Nevertheless, there was consensus that, among other things, "a computer-literate workforce is necessary to maintain our national defense and to improve our national productivity."

Integrating computer literacy into regular curricula. When the advent of low-cost microcomputers made computers accessible to many more students in school, it became feasible to begin integrating computer-related skills and knowledge into the regular curricula. Although most school districts were still teaching about computers in their computer literacy courses, newer definitions of computer literacy emphasized the use of computers as intellectual tools for the learner.

In 1982, the Human Resources Research Organization, in conjunction with national experts on educational computing and classroom teachers, developed a sequence of universal computer literacy objectives, or strands of skill and knowledge domains, which were to be integrated into the regular math, science, social studies, and language arts curriculum (Hunter, 1983). These were as follows:

- Using and developing procedures. This strand emphasized procedural thinking as fundamental to both understanding and using computers.
- Using computer programs. In this strand, using a variety of computer programs was seen as prerequisite to understanding how computers can be applied to different kinds of tasks, and

what computers' capabilities and limitations are in doing those tasks.

- Fundamental concepts about computers. This strand was limited to a handful of very basic concepts, such as the idea of a stored program.

- Computer applications. This strand emphasized the understanding of computer-based systems, including the interaction of people, machines, data, and procedures in performing tasks.

- Impact of computers on society. This strand emphasized relationships among people and between individuals and society, and the effect of computer-based systems and related technologies on these relationships.

- Writing computer programs. This strand emphasized the systematic problem-solving processes involved in developing and writing computer programs for particular tasks.

The above objectives were similar to those of many other computer literacy curricula. However, they were a new departure in that they showed how to develop and apply computer skills in the context of all curriculum areas, rather than teaching these skills as a separate course.

The National Center for Educational Statistics sponsored a study of computer literacy conducted by Educational Testing Service, Human Resources Research Organization, and Instructional Computing, Inc. (Lockheed, Hunter, & Anderson, 1984). The study group provided a consensus definition of computer literacy, a conceptual structure, and a pool of survey questions to be used in assessing the state of computer literacy in U.S. elementary, junior high, and high schools. The definition agreed upon is as follows:

> Computer literacy may be defined as whatever a person needs to know and do with computers in order to function competently in our information-based society.
>
> Computer literacy includes three kinds of competence: skills, knowledge, and understanding. It includes:

1. the ability to use and instruct computers to aid in learning, solving problems, and managing information;

2. knowledge of functions, applications, capabilities, limitations, and social implications of computers and related technology; and

3. understanding needed to learn and evaluate new applications and social issues as they arise. (p. 8)

The pool of about 400 questions developed in this study represents a further advance in the concept of integration of computer literacy into the schools, because the questions attempt to identify myriad ways in which computer-related skills are learned, taught, and applied in all subject areas and in school and school district administration.

The idea that computers are not just objects of study but, more importantly, are useful tools for the learner was carried further by the National Assessment of Education Progress (NAEP) in preparing for its 1985-86 assessment of educational progress. NAEP prepared a series of "computer competence objectives" for students at ages 9, 13, and 17. The objectives are in three major categories -- computer science, knowledge and attitudes about computers, and computer applications. In particular, the computer applications category stresses the "computer as useful tool" concept: It emphasizes students' abilities to use computers to improve the students' information-handling and problem-solving abilities in the context of various subject areas. For example, word processing would be a means to help students improve their abilities to express ideas clearly and concisely in written form, and computer graphics would be a means to help students analyze and communicate the results of science lab

experiments or business data procesing (NAEP, 1984).

The National Science Board (NSB) Commission on Precollege Education in Mathematics, Science and Technology, in its report entitled Educating Americans for the 21st Century (1983), recommended a list of computer competencies for all students. Among these were:

> Experience in using the computer as a tool, which should include experiences in the use of standard applications software such as word processing systems and filing systems.
>
> Ability to use a computer language to do problem-solving tasks in the context of normal academic experiences . . .
>
> General understanding of the problems and issues confronting both individuals and society as a whole in the use of computers, including the social and economic effects of computers, the history and development of computing, and the ethics involved in computer automation. (p. 100)

The National Commission on Excellence in Education in its report, A Nation at Risk (1983), recommended that all students seeking a high school diploma should be required to take a core curriculum of the "Five New Basics" -- English, mathematics, science, social studies, and at least a half year of computer science. They recommended that students be able to use the computer in the study of the other four basics and for personal and work-related purposes (p. 26).

Reassessing traditional curricula. More recently, study groups and professional societies have been going beyond the idea that all students should know about computers and be able to use them effectively for learning and working. These groups and societies are now focusing on a more in-depth analysis of the implications of computer-related technologies for information-handling and problem-solving methods within various school

subjects.

In conjunction with the NSB Commission's working groups, the Conference Board of the Mathematical Sciences produced a working paper entitled The Mathematical Sciences Curriculum K-12: What Is Still Fundamental and What Is Not (1983). This Group argued that

> The widespread availability of calculators and computers and the increasing reliance of our economy on information processing and transfer are significantly changing the ways in which mathematics is used in our society. To meet these changes we must alter the K-12 curriculum by increasing emphases on topics which are fundamental for these new modes of thought. (p. 1)

Their recommendations included the following:

- That substantially more emphasis be placed on the development of skills in mental arithmetic, estimation, and approximation, and that substantially less be placed on paper and pencil execution of the arithmetic operations.
- That direct experience with the collection and analysis of data be built into the curriculum, to ensure that every student becomes familiar with these important processes.
- That the content, emphases, and approaches of courses in algebra, geometry, precalculus, and trigonometry be reexamined in light of new computer technologies.
- That research be done on the math skill needs of students who seek vocational employment.
- That changes in secondary programs be carefully orchestrated with the expectations of colleges and employers.
- That strong national leadership and cooperation be provided by teachers, mathematicians, and public policymakers to meet the challenges.

In science, the NSB report includes the following recommendations:

> The required curriculum up to and including the 10th grade should use what is now available and develop

further material that will:

> demonstrate the relevance of science and technology to many important aspects of the students' lives and their community;
>
> develop the higher cognitive strategies of problem solving and decision making. These process skills are as basic to our needs as those of computation and communication.
>
> be structured around the interaction of science and technology with the whole society. Examples: smoke detectors and radioactivity; acid rain effects; energy conservation.

The Carnegie Foundation for the Advancement of Teaching, in its report entitled <u>High School: A Report on Secondary Education in America</u> (Boyer, 1983), provides a somewhat different perspective on computer literacy. This report says

> The great urgency is <u>not</u> "computer literacy" but "technology literacy," the need for students to see how society is being reshaped by our inventions, just as tools of earlier eras changed the course of history. The challenge is not learning <u>how</u> to use the latest piece of hardware but asking <u>when</u> and <u>why</u> it should be used. . . . It is increasingly important for all students to explore the critical role technology has played throughout history and develop the capacity to make responsible judgments about its use. (p. 111)

Summary -- An Evolving Definition of Computer Literacy

We have tried to make clear that the perceived needs, requirements, and definitions of computer literacy have been and continue to be evolving. There is no reason to think that this situation will stabilize in the foreseeable future. We have seen a gradual shift from a focus on computers as objects of study, to computers as tools in the traditional curriculum, to reassessment of the curriculum itself. As more and more people become computer users in more and more diverse settings, attempts to

make static, universal definitions of computer literacy will become less and less viable. However, for this paper's purposes, we offer the following working definition:

> Computer literacy may be defined as the ability to use computers and associated information technologies in ways which enhance one's productivity, creativity, and ability to solve problems and communicate effectively with others.

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THE STATUS OF COMPUTER LITERACY IN VOCATIONAL EDUCATION

If one defines computer literacy functionally -- i.e., "whatever a person needs to do with computers in order to function effectively in a particular role" -- then one would expect to see the integration of computer-related tools, methods, and concepts into the curricula of nearly every vocational education program. Evidence of this integration would be reflected in some of the following ways:

- Job and task inventories for office and industrial occupations would reflect the computer-related tasks performed and skills and knowledge required in those occupations.
- Curriculum guidelines published by state and regional education agencies for these occupational programs would reflect computer-related skills and knowledge.
- Vocational education conferences would have sessions and papers on the integration of computer-related skills into vocational education courses.
- Secondary schools would be sponsoring or conducting in-service workshops for vocational education teachers, to increase their computer-related skills.
- Teacher-training institutions would be preparing new vocational education teachers to incorporate in their instructional programs computer-based tools, methods, and media.
- Textbooks and other learning materials used in vocational education would incorporate computer-based methods and materials.
- Software and educational publishers, seeing a market in vocational education for software designed for vocational education curricula, would be offering computer programs to fit into the various curriculum areas.

As noted previously, a sampling of the first indicator -- job/task inventories -- is discussed in Appendix A. While a full survey of the other indicators is beyond this paper's scope, a brief review is given

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below.

State and Local Education Agencies

According to an October, 1984, survey of state education agencies, 20 states had passed laws requiring or recommending some form of computer literacy instruction in their K-12 schools (Barbour et al., 1984). The trend toward state-mandated computer literacy continues, although states differ widely in implementing their mandates.

Texas, for example, requires that all middle-school students take a half-year course that covers the history, terminology, applications, and social and ethical implications of the computer along with some introductory programming. On the other hand, Wisconsin's 1983-84 working draft Guidelines for Instructional Computer Use in Education (1983) instead emphasizes integrating computer-related skills and knowledge into traditional courses:

> Knowledge of the computer is basic to an understanding of the full range of procedures that may be applied to organizing information and solving problems in fields as diverse as mathematics, science, social sciences, business, industry, language and the arts. Integrating computers into the school curriculum can expand educational opportunities for all students. . . . Curricula should be designed to take full advantage of the multidisciplinary potential of the computer. (p. 1)

Thus, many state education agencies are formulating policies regarding computer literacy curricula. However, few of these directives relate specifically to vocational education. An exception is California.

The California State Department of Education Office of Vocational Education (Honig, Thompson, & Del Buono, 1983) has published a draft

Computer Literacy Guide for Business Education that addresses three levels of computer literacy: awareness, operations, and competence. At the "awareness" level, the Guide specifies objectives such as the following:

> Given an assignment to describe the various ways in which source data are converted to machine readable medium [sic], the student will describe the characteristics and features of the following as they are used in the input phase of automated information handling and indicate at least one business application where each input medium is commonly used: direct keyboard entry; mark sense card; magnetic tape; magnetic disk; optical character recognition; magnetic ink character recognition; electronic data transmission; bar code; electronic wand; voice input; punched card. (p. 5)

At the "operational" level, the Guide suggests objectives such as the following:

> Given a microcomputer or terminal with which the student is familiar, a data base management program, and appropriate reference manuals, the student will load, initialize, and execute a sample program furnished by the program supplier. (p. 11)

At the "competence" level, the Guide suggests objectives such as the following:

> Given a microcomputer or terminal with which the student is familiar, an electronic spreadsheet program, and appropriate reference manuals, the student will demonstrate the ability to apply the program to a typical task such as a balance sheet, a breakeven analysis, etc. (p. 13)

The California competence objectives illustrate the idea that students need to learn not just rote procedures but how to apply computer-based tools to their job tasks.

Kapp and Knickerbocker (1983) surveyed state vocational education directors to determine whether microcomputers were being purchased for

vocational education, how the computers were being used, and the percentage of teachers using microcomputers. At that time, 35 of the states and territories had bought microcomputers with vocational funds. Forty-two percent of junior high and high schools had purchased more than 50 microcomputers, although it is unclear whether all of these were for vocational education. The use most frequently mentioned (96 percent of the respondents) was word processing. Seventy-eight percent of the respondents said that fewer than 50 percent of their teachers were using microcomputers.

Curriculum Guidelines

A few recent local and regional curriculum guidelines for office, drafting, and accounting occupational areas were reviewed for this paper (e.g., Bush et al., 1981). Although many of the vocational programs did include computer-related competencies or topics, these were usually not integrated into the regular curricula, but rather were tacked on as separate courses in computers or information processing. It must be emphasized, however, that the present paper's resources precluded a systematic evaluation of all published curriculum guides.

Conferences

It appears that computer literacy is a quite recent topic at vocational education conferences. In 1982, the "First Annual Microcomputers in Vocational Education Conference" was held in Madison, Wisconsin (Rodenstein & Lambert, 1982). A collection of papers addressing

a wide range of topics was distributed in handbook form at this conference. Some of the papers reflect a reevaluation of vocational education courses in light of the new accessibility of computer-based tools. Based on available information, however, it does not appear that vocational educators have been participating in anywhere near the number of local, regional, and national computer literacy conferences that their academic education counterparts have.

Teacher Training

The 1983 Kapp & Knickerbocker study cited earlier found that nearly every state or territory had made an effort to provide some information on microcomputers to its vocational educators. The information sessions lasted from one-half hour to 60 hours and were held on the local, district, regional, and state levels.

An example of state-supported teacher training is the work of the Vocational Education Services (VES) at Indiana University. VES conducted a series of two-day microcomputer workshops last summer and fall for vocational educators and administrators, and it received a 14-month grant from Indiana to become a computer literacy training center for teachers in six counties of the state.

Textbooks

A systematic analysis of current textbooks used in vocational curricula is beyond this study's scope. One popular word-processing textbook is Word/Information Processing Concepts, by Bergerud and

Gonzalez (1981). The text takes a systems approach to office automation, teaching concepts as well as analytic methods. It addresses the process of change in offices and teaches how to manage all aspects of change. If such a textbook was used together with hands-on experience with a variety of office automation equipment, procedures, and tasks, it seems that the resulting course would give the student a solid understanding of office information processing. The concepts and facts included in the textbook embody an excellent example of computer literacy as defined in this paper.

Software Developments

Over the past four or five years, educational and software publishers have been investing heavily in developing and marketing educational software, but until recently, very few of these software programs have been for specifically vocational education curricula. For example, it appears that there is no published typing curriculum textbook that uses word processors (although such a textbook will certainly appear shortly).

In 1982, the Curriculum Publications Clearinghouse at Western Illinois University sought to catalogue the available industrial education applications software. They found about 20 programs. In contrast, there are thousands of offerings for K-8 education. At the college level, there is, for example, Southwestern"s "Computer-Oriented Accounting" course, which has been published for many years.

There are a few computer-aided design (CAD) software offerings intended for secondary-school industrial arts curricula. For the most part, however, vocational educators are trying at present to adapt software

designed for business and industry.

In sum, it appears that educational publishers have not seen vocational education as a ready market for specially designed software or courseware. Of course, this will change as the market becomes more apparent.

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COMPUTER LITERACY NEEDS IN TOMORROW'S WORKPLACE

Lacking a clear vision of tomorrow's workplaces, educators and their students could well waste billions of dollars and person-years in counterproductive efforts to acquire irrelevant or low-priority skills and knowledge. Nearly everyone agrees that we are in the midst of an information revolution that is changing the nature of the U.S. and world economies. Computer and communications technologies are central driving forces in this revolution, which is still in its early stages. It is impossible to predict with certainty what occupational structures will prevail in twenty or thirty years, much less what the specific skill and knowledge requirements of those occupations will be.

Yet the rationale for striving for "computer literacy," especially in vocational education, is to prepare young people for work in the information-rich, highly computerized offices, homes, farms, and factories of the future. Thus, computer literacy is a very high-risk educational venture. It is high-risk both because of its uncertain payoffs in terms of its relevance to tomorrow's jobs and because of the high costs of acquiring computer equipment and providing the teacher training programs needed for adequate computer literacy curricula.

The Dilemma of Technological Change

> Productive members of society will increasingly be expected to modify, upgrade, and update their knowledge and skills in response to pace f technological change at least as rapid as occurred during the great industrialization of America a century ago . . . Given the uncertainty regarding the skill requirements of the economy, it is essential that the education of America's

young people is designed to enhance their abilities to adapt as necessary to these changing requirements. (Education for Tomorrow's Jobs, 1983)

In the past, new computer-related programs of study typically have been oriented toward the technology of the preceding computer generation. In the early 1970s, computer-related curricula were oriented toward batch-processing and keypunching, while the new technology was moving toward interactive timesharing systems. In the mid-1970s, when microcomputers were appearing on the market, educational programs were being upgraded to reflect the advent of timesharing. In the late 1970s and early 1980s, when the availability of general-purpose applications programs was rendering programming skills obsolete for most computer users, thousands of schools began instituting courses to teach all students programming on microcomputers. Now, when technological advances are being made which will render many data-entry-specialist jobs obsolete, many schools are instituting training in data entry. And now, when computer-based work stations in business offices are integrating word processing, data processing, and communications functions, many schools are instituting training for word-processing-specialist jobs on dedicated word-processing machines.

How serious a problem is this rapid technology change for teachers and students in vocational education? The answer depends entirely on the courses' goals and objectives. If the students are acquiring fundamental concepts and skills in information-handling and problem-solving, then the characteristics and limitations of the particular machines and methods are

more or less incidental. If, on the other hand, students are merely being trained to operate a particular device or program, then the consequences of using obsolete or near-obsolete equipment are very serious.

For the foreseeable future, changing technology will be a fact of life in all workplaces. Learning to use new machines and new kinds of machines will be a part of every job. Even more significantly, learning new ways of organizing and managing information will be a continuing process for everyone.

Consider, for example, the hypothetical career of a woman who has been a secretary for the past five years. She may have begun performing a wide variety of tasks for her employer, including typing on a typewriter. Then the organization set up a centralized word-processing center, and she was transferred there, to specialize in operating a new dedicated word processor. After a year, the company reorganized and she transferred to another division where there was a different kind of word processor that communicated with an office data-processing machine. Now the company has acquired general-purpose personal computers, and she is learning to use not only a word-processing program for the personal computer but also an electronic spreadsheet, a database management program, and communications programs. She is setting up procedures for transferring data from the spreadsheet to the word-processing program and is organizing the disk-file library for her group.

Viewed in the context of this fairly typical career path, it appears that the particular equipment used in the secretary's vocational education program would make little difference. What <u>could</u> make a difference,

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however, are the fundamental skills, knowledge, and attitudes related to learning new methods of handling information, developing procedures, learning how to learn about new machines, and collaborating with co-workers in problem-solving situations. All of these would affect her ability to adapt successfully and productively to new job requirements.

The Uncertain Impact of Automation on Employment

There is a broad range of views in the scholarly literature and popular press about how and to what extent computer-based automation will affect U.S. economic and employment patterns. One extreme claims that the future will require a much less skilled workforce; the other, that the future requires a far more highly skilled workforce.

The less-skill perspective. One scenario of technology's impact on future job skills is that, essentially, machines will do it all. This view implies that many future tasks will be simplified as machines perform the majority of complex operations.

The widely quoted thesis of Levin and Rumberger (1983) is that:

> . . . the expansion of the lowest skilled jobs in the American economy will vastly outstrip the growth of high technology ones; and the proliferation of high technology industries and their products is far more likely to reduce the skill requirements of jobs in the U.S. economy than to upgrade them. (p. 2)

Levin and others note that, according to U.S. Department of Labor predictions, the largest employment increases in the 1980s will be in low-skill jobs such as janitors, nurses' aides and orderlies, waitresses and waiters, and sales clerks.

The more-skill perspective. Most analysts disagree with the above

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perspective. For example, the analysis of Leontief and Duchin (1984) results in a nearly opposite conclusion. They developed an input-output model of the U.S. economy using four different scenarios of computers and various forms of computer-based automation being progressively introduced into 89 individual industries. Their model details the probable effects that these technological changes will have on outputs and inputs of all goods and services, and in particular on the demand for labor services in 53 different occupations. They find that

> The intensive use of automation over the next twenty years . . . will involve a significant increase in professionals as a proportion of the labor force and a steep decline in the relative number of clerical workers. (p. 1)

Automation seems likely to affect clerical workers first and perhaps most strongly. "It has been estimated that at least 30 percent of clerical jobs will be lost by 1990 as the impact of the word processor makes itself felt" (Farley, 1980). A 1978 report to the president of France projected that by 1990, 30-percent fewer workers would be needed to produce a given volume of work in the insurance and banking industries (Faddis et al., 1982).

The Education Commission of the States in its report, <u>The Information Society: Are High School Graduates Ready?</u> (1982), agrees with the thesis that "by examining the skills needed in tomorrow's labor force we can better prepare workers for the changing conditions they will encounter" (p. 1). This report points out that other factors besides breakthroughs in technology -- factors such as "advances in new knowledge and increased education levels of the work force" -- are significantly related to

economic growth. It notes that occupational growth throughout the 1980s is projected to expand most rapidly in the higher-skilled, technical occupations: "Tomorrow's workers will likely need improved skills in the selection and communication of information. Many of today's skills considered to be of a 'higher' level are the potential basic skills of tomorrow" (p. 1). According to the report, these skills include

- evaluation and analysis skills
- critical thinking
- problem-solving strategies
- organization and reference skills
- synthesis
- application
- creativity
- decision-making given incomplete information
- communication skills through a variety of modes. (p. 6)

A third view: transformation. Part of the reason for the discrepancies in these views of the future is that our society is in a period of transformation or paradigm shift, as characterized by such writers as Toffler (1980) and Ferguson (1982). Toffler's view is that in the industrial age, the "workers" were trained to perform repetitive tasks requiring varying degrees of skill, whereas the "thinkers" were educated to solve problems, make decisions, and manage workers and information. If one imposes, or overlays, this industrial-age paradigm on our increasingly technological workplace, one sees lowered skill requirements for the "workers." A frequently-cited example is the claim that word processors

reduce typists' skill requirements (automatic spelling checkers, automatic formating, etc.). An example of this kind of thinking is reported by Menosky (1984).

An alternative view was characterized succinctly in High School: A Report on Secondary Education in America (Boyer, 1983), in discussing the tracking of students into "academic" and "nonacademic" paths:

> Students are divided between those who think and those who work, when, in fact, life for all of us is a blend of both. (p. 126)

If one applies this "working and thinking" paradigm to the claim that word processors lead to reduced skill requirements for typists, one arrives at a different conclusion. A "thinker" using a word processor may be performing many operations and decisions that formerly were regarded as requiring higher order skills -- operations such as planning the organization of document files, designing file templates for repetitive correspondence, writing procedures using variables, programming keyboard macros, developing procedures for integrating data files with documents, selecting appropriate typestyles and document formats, developing a library of standardized templates, and so forth.

It appears that a "worker versus thinker" paradigm has led such analysts as Levin and Rumberger to believe that computer-based technologies will result in the need for a less skilled workforce. These analysts refer back to the ways in which industrialization resulted in worker specialization and lowered skill requirements, and they imagine that the same trends will continue with computer-based automation. They do not take into account that computers can be used to extend the intellect,

thereby allowing people to be more creative and effective problem-solvers while their computers perform the rote, repetitive tasks. In this manner, a person can add value to the product or service involved, thereby contributing to the productivity of the overall economy.

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CONCLUSIONS AND RECOMMENDATIONS

Four Central Questions

The following points summarize the main conclusions this paper draws about the four questions posed at the outset.

What is computer literacy? . . . Definitions and requirements for computer literacy have been changing and will continue to change for the foreseeable future. In general, definitions and curricula have moved from a focus on learning about computers, to using computers as tools and integrating the use of these tools into the regular curricula, to reassessing and restructuring basic curricula in light of computer-based methods of working.

How important is computer literacy in preparing students for the workplaces of the information society? . . . The importance of computer literacy depends on how that term is defined. Most (although not all) analysts and futurists believe that for the United States to sustain a productive, competitive economy in a highly automated, information-based society will require workers with higher levels of problem-solving, decisionmaking, and communications skills than were needed in the industrial age. Thus, "computer literacy" eventually translates into "information-handling, problem-solving" know-how.

Learning when to use which computer-based tools, and using these tools in a productive manner, is more important than learning about technology. Elementary abilities to operate computers and use computer-related terminology can be expected in students entering vocational programs, due

to an increased emphasis on computer literacy in elementary and junior high schools and to state-mandated computer literacy requirements for all students.

What computer-related skills and knowledge are needed or will be needed? . . . In all three of the occupations examined Appendix A (secretarial, accounting, and drafting work), the most obvious common need is the ability to learn to use new technologies in the changing workplace. From this standpoint, a training program cannot be directed simply toward rote memorization of a specific machine's or computer program's procedures. Instead, understanding concepts and functions and being able to apply them in a variety of contexts is essential.

Improvements in computer-based work stations have increased their general utility. A wider variety of computer-based tools for information analysis and communication is now available on low-cost work stations. This leads to less specialization in office occupations and a greater degree of integration in data- and information-processing functions. Because computer-based technologies will continue to be improved and changed (rather than standardized), problems of file and machine incompatibilities will have to be dealt with by office workers. Again, this will require conceptual understanding and problem-solving skills.

What needs to be done to make vocational education programs more responsive to students' needs for computer literacy? . . . First, vocational education must find methods not only to respond to the changing workplace but to anticipate changes in it. As Appendix A points out, existing methods for providing job/task information through task

inventories are out-dated, and new methods must be invented. Otherwise, vocational educators risk investing large amounts of time and money in developing curricula and operating programs that teach obsolete or low-priority skills and concepts. As part of this, vocational education institutions and programs must become more flexible, and their spending patterns must take into account the need for a greater proportion of spending on program development as opposed to program maintenance.

∘Second, in developing and reassessing curricula the focus should not be solely on behavioral definitions of tasks. Instead, there must be greater understanding of the cognitive processes involved in handling information and solving problems on the job. Task analyses thus should focus more on such job aspects as problem-solving, decisionmaking, and troubleshooting.

Summary -- Where Computer Literacy in Vocational Education Should Be Heading

Computer literacy must be headed toward a functional integration into vocational education curricula and methods. If it is not, these curricula will become hopelessly out-of-date. Vocational education runs the risk that the traditionally separate computer-specialist curricula (e.g., as described in Appendix B) will serve as a model for isolating computer-related skills into separate courses. However, the increasing pressures placed on vocational education programs by industry, the popular press, and parents and the rapid developments in appropriate software make such isolation unlikely.

It is possible that vocational educators who until now have not been

involved in computing could "leapfrog" over the earlier, evolutionary stages of computer literacy. They could skip the "computer as object of study" stage, move immediately into the "computer as a tool of the learner" stage, and begin to redesign curricula to bring them in line with modern workplaces. In this process, computer-based tools and methods should be integrated into all subjects in the regular curriculum, rather than being isolated as a separate subject of study. But this, of course, implies massive teacher reeducation.

APPENDIX A:

COMPUTER LITERACY REQUIREMENTS IN THREE SAMPLE OCCUPATIONS

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CAN COMPUTER LITERACY REQUIREMENTS BE BASED ON JOB/TASK INVENTORIES?

It has been assumed by training developers that the design of effective vocational education and training programs must be founded on detailed and systematic analyses of the tasks to be performed during a job. But conducting empirical task studies is a costly undertaking, usually beyond the resources of an individual school. Therefore, regional and national centers and consortia have been established to provide job/task inventories and job-relevant catalogues of performance objectives, criterion-referenced measures, and performance guides.

In examining available job/task inventories in three sample occupations, we have three purposes. These can be posed as questions:

1. What are the computer-related skills and knowledge needed by workers in different occupations? Job/task inventories and catalogues of performance objectives should provide a systematic, comprehensive basis for answering this question.

2. What computer-related skills and knowledge are common across occupations, and therefore might be grouped together in "computer literacy" courses for vocational educational students? Again, the job/task inventories and catalogues should provide a comprehensive basis for analysis.

3. What information is available to vocational curricula developers and teachers about the computer-related skills and knowledge needed by their students? We will attempt to assess the availability and usefulness of job/task inventories and catalogues from the standpoint of those attempting to revise vocational curricula to include computer-related skills and knowledge.

The Three Sample Occupations: Their Selection and Inventory Sources

The COMTASK component of the 1 1/2-year project in high technology education undertaken for the U.S. Department of Education by the Office for Research in High Technology Education at the University of Tennessee, Knoxville, attempted to obtain all the available job/task inventories in three occupational areas from a variety of research centers throughout the United States. COMTASK's three occupational areas were as follows:

Secretarial - Including such job titles as secretary, legal secretary, word processing administrative support secretary, executive secretary, word processing correspondence specialist, typist, and word processing specialist.

Accounting - Including such job titles as accounting clerk, accounts payable clerk, accounts receivable clerk, billing clerk, credit clerk, procurement clerk, purchasing clerk, supervisor, accounting clerk, bookkeeper, and payroll clerk.

Drafting - Including such job titles as architectural drafter, computer-assisted drafter, landscape drafter, mechanical drafter, and engineering technician.

A focus on the secretarial area is clearly justified, because it represents the largest enrollment in vocational education programs. Drafting was selected because it is being affected so radically by computer-aided design and drafting systems. Accounting was selected because computer applications in accounting date back to the 1950s and are older than computer applications in any other occupational field.

To obtain available job/task inventories and catalogues in the three areas, COMTASK sent requests to the following organizations:

- Vocational-Technical Education Consortium of States (V-TECS)
- Vocational Studies Center, University of Wisconsin-Madison
- Michigan Occupational Data Analysis System (MODAS), Michigan State University
- Agriculture and Natural Resources Education Institute (ANREI), Michigan State University
- Tennessee Valley Authority (TVA)
- East Central Network for Curriculum Coordination, Sangamon State University, Springfield, Illinois.

After several months, twelve job/task inventories were obtained from these sources.

This paper has taken advantage of COMTASK's work by using the same sample occupational areas and inventories. However, the findings given below are our own.

Findings

Secretarial occupations. Recent inventories were obtained for the following job titles from the sources cited parenthetically:

- Secretary (Wayne State University, 1982)
- Executive Secretary (University of Maryland, 1980a)

- Word Processing Correspondence Specialist (University of Maryland, 1980b)
- Word Processing Administrative Support Secretary (University of Maryland, 1979)
- Clerical-Secretarial (Wisconsin Vocational Studies Center, undated)
- Legal Secretary and Court Reporter (Keeton & Briscoe, 1976)
- Word Processor (Tennessee Valley Authority, unpublished)

Only two of these inventories -- the Word Processing Correspondence Specialist and the TVA unpublished job analysis for Word Processors -- reflect the use of word processors. Amazingly, the inventory of 63 tasks for "Word Processing Administrative Support Secretary" makes no mention of using word-processing equipment. In a typical task statement, the secretary uses a typewriter to type correspondence, purchase orders, etc. None of the published inventories reviewed reflect the use of data communications, database management systems, electronic spreadsheets, or other computer-based office automation equipment.

Accounting occupations. Three catalogues and task lists were obtained (Indiana State University, 1983; Alabama Division of Vocational Education, 1978; Agriculture and Natural Resources Education Institute, undated). However, these were almost totally lacking in computer-related task statements and would not provide a useful basis for updating curricula to reflect computer-based methods of bookkeeping and accounting.

Approximately 300 task statements were included in the three job/task inventory and catalogue documents reviewed. Nearly all of the task statements assume manual methods and tools for managing information (filing cabinets, ledgers, journals, etc.) and they assume that computations will be performed with calculators. The most recent catalogue (Indiana State University [ISU], 1983) assumes all-manual methods of accounting, using computer printouts only for tasks such as the following:

> Audit Accounts Payable/Receivable Computer Records. Given a computer printout, manual records, tools and equipment, audit accounts payable/receivable computer records. (ISU, 1983)

Since accounting was one of the earliest computer applications in both government and industry, it is surprising to see a 1983 accounting task catalogue that assumes only paper-and-pencil methods of bookkeeping and accounting.

Drafting occupations. Two brief task inventories were obtained: one entitled "Architectural Draftsperson" and one entitled "Architectural Drawing/Blueprint Reading." However, neither of these reflects the use of computer-aided design and drafting tools.

Summary Assessment of Sample Job/Task Inventories

From the standpoint of computer-related tasks, skills, and knowledge, the inventories examined essentially were useless. Even job/task catalogues published as recently as 1983 had few or no computer-related tasks included.

Nearly all of the secretarial job/task inventories ignored the use of word processors, not to mention other kinds of general-purpose computer programs appropriate to an office setting. The same was true of the bookkeeping and accounting inventories, even though accounting is one of thhe oldest computer applications. In drafting, few inventories were available. In those that were, computer-aided design and graphics programs were not mentioned.

The one job/task listing that did identify several computer-related tasks (ANREI, undated) illustrates a major weakness found in the inventories reviewed: computer-related tasks were described almost solely in behavioral terms (e.g., "manipulate switches, keys, and levers to create a program to control record format operations") but the far more important (particularly for education and training) cognitive components of the tasks were ignored. In reading the task lists, one gets the impression that the one thing workers don't do is <u>think</u>. According to the task lists, they rarely make decisions, analyze information, solve problems, apply principles, make trade-offs, etc.

Techniques for analyzing tasks for their cognitive components are in their infancy (e.g., Bond et al., 1984). At the least, however, it would help in developing computer-related curricula if job/task analyses would state the task's purposes or goals from the viewpoint of the task performer. Such information would be useful in grouping related tasks for instructional analysis and sequencing of instruction. For example, in word processing, statements such as "embeds control characters into text strings" are less useful than statements about the underlying purpose of the operations. The embedding might be done to specify or modify a document or page formats, to document procedures, to reorganize document content, etc. -- but such purposes are accomplished through <u>different</u> behavioral operations, and on <u>different</u> machines or software. A person attempting to become computer literate needs to develop a cognitive framework to understand basic purposes and functions and to transfer these understandings across different machine environments.

At present, these job/task inventories take several years to prepare; they rely on survey responses from workers in representative firms. However, their methodologies apparently do not attempt to take into account (e.g., by using job incumbents in cutting-edge industries or companies) the fact that jobs are changing. Thus, from our review it appears that the present system of creating and

updating job/task inventories is of little value in developing up-to-date curricula or even identifying the skills and knowledge needed for computer-related tasks in workplaces that have continual changing technological applications.

COMPUTER LITERACY REQUIREMENTS IN THE THREE SAMPLE OCCUPATIONS

As indicated in the prior section, three sample occupational areas were selected for study here: secretarial, accounting, and drafting work. This section gives our assessment of computer literacy requirements in these three areas.

Secretarial Occupations

Secretarial training programs are among the most successful vocational educational programs, in terms of their employment results (National Institute of Education, 1981, p. 219). This justifies paying attention to the continual need for improvement in and modernization of vocational education secretarial programs.

Office methods and systems for handling information are changing, due to continuing improvements and cost reductions in computer- and communications-based technologies. The relationships among the organizational groups and subsystems of even small businesses are being rethought, due to new technologies for gathering, organizing, storing, retrieving, and communicating information. This has major implications for secretarial occupations.

Word processing. Five or ten years ago, word-processing machines cost tens of thousands of dollars and were thought to require "word-processing specialists" to operate them. Now, word-processing programs are available for $50 to $400, and they can be used with general-purpose desktop computers. A business person who pays relatively little for a word processor does not expect to have to hire or train a specialist to operate it. Rather, word processing is an everyday tool of anyone in an office who needs to produce written documents. Thus, one shouldn't need a specialized course of study to learn to use word processors. Rather, they should be a normal, everyday tool in the secretarial curriculum, just as using pencils, paper, and books are everyday tools.

Information-handling systems. Even more significant than the proliferation of word-processing capability in offices is the fact that a wide variety of data management, data processing, communications, and other functions can easily be performed by non-specialists using the general-purpose computer that is the heart of

the modern office work station. This allows for greater integration of various informationhandling functions than has been possible in the past. It also means continual changes in information-handling systems for the foreseeable future. (See D'Onofrio, 1983, for a discussion of this point.)

This trend toward integrated work stations has many implications for computer literacy. First, this trend means that a narrow, specialized training in dedicated word-processor operations is less valuable in the job market than are general information-processing skills. Second, it means that a secretary needs to be able to operate new kinds of software. Communications, spreadsheets, data bases and accounting programs are becoming as important as word-processing systems. And third, one can therefore expect less, rather than more, specialization of office jobs.

Secretarial tasks. COMTASK, as part of its efforts to develop a new task inventory system, put together a list of tasks performed by secretaries who use word-processing equipment. The following are some examples from this list:

- Motivate operators to accept new equipment
- Demonstrate equipment use
- Schedule maintenance of office equipment
- Prepare user manuals
- Review and analyze new and revised procedures and implement necessary changes
- Recommend changes and improvements to the system for better utilization of equipment
- Control security of disks
- Control security of confidential information
- Reprogram word-processing machine
- Determine which forms to use
- Select typestyles to use for publications
- Compose narrative summary of charts, graphs, numerical projections, etc.
- Arrange typed data in correct order for computer access
- Create data files
- Sort database records chronologically, alphabetically, or numerically
- Conduct search of data base
- Select and enter plotting commands for graphic display of data
- Select program to use on computer (word processor)
- Establish telecommunication link
- Monitor telecommunication transmission
- Determine sources of machine or program malfunctions

While these are just a few of the tasks from COMTASK's list, they suggest the diversity of tasks and equipment involved in today's

secretarial work, as well as some of the analytic, problem-solving, and troubleshooting skills required.

Computer literacy training in today's offices. From a survey of corporations and small businesses (Wujik et al., 1983) TALMIS estimates that 43 percent of companies with more than 50 employees provided computer literacy training for their office workers in 1983. Computer literacy training was expected to take place in 53 percent of companies with more than 50 employees and 18 percent of smaller companies in 1984. (Wujik et al., 1983, p. 5.) By 1987 the penetration of training is expected to be 86 percent in larger companies and 20 percent in smaller ones. This type of training activity is expected to peak in 1986 or 1987 and then drop off (presumably because by then most workers will have had the training needed to make them computer literate). In dollar figures, TALMIS estimates that companies with 50 or more employees will have spent approximately $400 million on the development or purchase of computer literacy training materials in 1983 and $625 million in 1984.

The TALMIS study shows that secretarial and other office employees in the companies surveyed were being trained to use a wide variety of software on general-purpose computers, including word processing, electronic spreadsheets, graphics, data base management, and computational programs. Executives and professionals in the offices were receiving training in the same subject areas, but with less emphasis on word processing and more on the other areas.

The need for higher level skills. According to nearly all of the analyses reviewed for this study, it appears that secretarial jobs will continue to require greater decisionmaking skills, more analytic ability, greater adaptability, and better skills in communications and interpersonal relations. In partial support of this, understanding the basic concepts of systems analysis, data processing, and telecommunications are seen as necessary (Hynek & Schluter, 1983; Patterson et al., 1982; D'Onofrio, 1983). A fairly extreme version of this point of view was expressed by Stewart (1979):

> The day may not be too far off when secretarial jobs will require a master's degree in business administration and be regarded as an entry-level step into management . . . there will be more creative-type positions, few dog-work-type tasks, and there will be far more tasks. (p. 15)

Learning to learn about computers. What, then, is the most important computer-related skill a person preparing to be a secretary could have? Clearly, one cannot point to any given device or program and say "This is the kind of machine one must be trained to operate." Even the seemingly generic skill of keyboarding is suspect (as an overriding priority) in a world where voice input, optical scan

input, and direct computer-to-computer data transfer could reduce keyboarding demands overnight.

The most powerful computer-related ability that a secretary could develop is the ability to learn the capabilities, limitations, and operations of a particular computer-based system when the need arises. This concept, and its related attitude of confidence, can be encouraged by an educational environment that expects students to learn how to learn. For example, students learning to operate an unfamiliar word-processing program would not be taught step-by-step operational procedures. Rather, they would be introduced to the program's basic functions and would be given a user's manual and/or the online helps and program menus. They would be asked to solve problems and accomplish tasks of progressive complexity. Students, working independently or in small groups, would then develop the confidence and skill to teach themselves how to use available information to solve new problems and accomplish new tasks.

Prerequisites to independent problem solving. Reading, writing, oral communications, procedural thinking, keyboarding, familiarity with the characteristics of electronic storage media, and a minimal computer-related vocabulary are prerequisite to success in independently learning how to solve problems and perform tasks using computer-related skills.

Using applications programs. In the near future, secretarial students need to learn how to use word-processing and associated spelling- and grammar-checking programs; electronic spreadsheets; data management programs; graphics programs; and communications programs. Since these are constantly being improved, tudents must learn not only the particular program's specifics but its basic functions and its capabilities and limitations.

Handling file incompatibility. The ways in which applications programs allow for integration of text, graphics, and data vary. This fact is especially significant to a secretary, who may be expected, for example, to maintain a name-and-address file using a data management program and then to apply selected records from that file to a repetitive-letter mailing list using a word-processing program.

For the next few years, incompatibility of files across different applications programs will continue to be a problem. Even within the world of word-processing programs, there are problems of file incompatibility. Various professionals, managers, and others within an office may be using different word-processing programs, and a secretary may be caught in the middle -- expected to edit, revise, or finalize documents written on different word-processing programs. Again, the secretary's ability to understand these programs' capabilities and limitations becomes important.

Learning materials. Fortunately for teachers and students in secretarial training programs, there are hundreds -- perhaps thousands -- of books, interactive tutorials, and other learning aids commercially available to help teach the subjects discussed here. The IBM Guide to Learning (Hunter et al., 1984) reviews dozens of materials on each of these subjects. These are intended for IBM-PC users, but materials exist for most personal computers. The Guide to Learning also provides sample course syllabi for word processing, spreadsheets, graphics, database management, and communications.

Accounting and Bookkeeping Occupations

Low-cost microcomputers affect the way in which bookkeeping and accounting are performed in both large and small businesses. In large companies, microcomputers provide a direct interface between the accountant or bookkeeper and the data-processing center. In small businesses, conversion from manual to computerized accounting operations is rapidly taking place.

The need for higher level skills. For bookkeepers and accounting clerks, increased automation has fewer implications for computer-related skills than it does for accounting and bookkeeping methods and principles. Manual methods of accounting and bookkeeping required a much greater proportion of time spent on such clerical activities as posting data and performing computations. Automated methods involve a greater proportion of time to be spent on analysis and decisionmaking (Hynek and Schluter, 1983; Rose, 1981).

Using computer-based programs. The obvious way for students to learn computer-based accounting and bookkeeping methods is to use accounting software in their regular accounting courses. They can use either programs available for personal computers (see, e.g., the programs listed in Rodenstein & Lambert, 1983) or packages designed for instructional purposes (Allen & Klooster, 1982; Pillsbury & Ripperger, 1982). Since these programs are constantly being improved, it is important for students to learn not only the program's specifics but its basic functions.

Prerequisite skills and knowledge. To use computer-based accounting and recordkeeping programs effectively, students need skills in keyboarding and computer operation. The particular skills needed will depend primarily upon the features of the computer's operating system, but normally would include such activities as formatting disks, listing files on a disk, transferring files from one disk to another, copying and erasing files, and troubleshooting in commonly encountered problem situations.

Basic concepts and knowledge about the capabilities, capacities, characteristics, and limitations of electronic storage media (disks,

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tape, random access memory, etc) are important prerequisites as well. Protecting the security and integrity of financial and accounting data on magnetic media is a very critical aspect of any job involving manipulation of these data.

Analyzing systems. Students planning to work in bookkeeping or accounting jobs need to be prepared for diverse and changing information-handling systems. One way to prepare is to develop a basic understanding of information-processing concepts and procedures. This involves primarily a functional understanding of the major steps in any processing cycle (source data, input, processing, output, communication, etc.) and the ways in which people, machines, and procedures interact to accomplish these steps. Such a conceptual understanding should enable the student to analyze the way in which any particular system operates.

Drafting Occupations

At least 30 jobs listed in the Dictionary of Occupational Titles have drafting skills as a major requirement. Job classifications are made aacording to the type of drafting, such as architectural or mechanical. Increasingly, drafters use computer-based systems for various aspects of their work. The general term "computer-aided design" (CAD) is used to encompass a wide variety of such computer-based systems and functions. Thus, computer programs of varius kinds are added to the drafter's standard toolkit of triangles, scales, and compasses.

Computer-aided design saves much time and can make an experienced CAD designer 50 percent more productive (Abram et al., 1983). The drafter is relieved of the need to hand-draw and redraw and to perform tedious computations.

Additional skills needed. According to Abram et al. (1983), skill in the use of computer-aided design and drafting tools must be built upon the traditional drafter's knowledge of and skills in principles of drawing, design standards, orthographic projection, descriptive geometry, and design processes. These conventional drafting skills and knowledge include, for example, construction of sectional views, application of measurement systems and dimensioning systems, construction of pictorial views, development of surface and plane intersections, use of drafting instruments, and use of orthographic third-angle projection in the construction of engineering drawings.

Use of computer-aided design and drafting programs requires additional skills and knowledge, primarily in the operation of the programs themselves. Entry-level job tasks for computer-aided

drafters are listed by Abrams et al. (1983, p. 10) in four task levels:

- Operate system -- e.g., manage files.
- Execute drawing assignment -- e.g., change existing drawings; document designs.
- Execute/change detailed drawings -- e.g., set up drawing format.
- Compose drawings -- e.g., rotate views; scale views.

Secondary-school programs and computer-aided drafting. The equipment and software needed for computer-aided drafting are now within means of some secondary schools. However, "it is uncertain whether the volume of classroom material and lab experiences that would have to be absorbed in an effective CAD program could be mastered within the time available for an associate degree program." (Abrams et al., 1983, p. 9.) If this is the case, then the appropriateness of such programs to secondary schools is similarly questionable.

Using computer-based programs. While full-scale CAD systems thus may not be available or appropriate to vocational students, particularly at the secondary-school level, there are relatively low-cost computer programs for microcomputers which could be used for learning some of the entry-level CAD tasks and skills. These computer-based drawing programs available for low-cost microcomputers would enable students to accomplish many more drawing assignments than they could by hand, and they could practice constructing sectional views, applying dimensioning systems, constructing details, etc. However, these low-cost microcomputer programs and their associated input devices all have important limitations in terms of learning drafting, and they should be reviewed carefully.

There are also computer-based systems intended especially for teaching computer-aided drafting. An example is CADET (Computer Aided Drafting for Educational Training), by ProConsul, Ltd. of Toronto, Ontario.

Shared Computer Literacy Needs

The secretarial, accounting, and drafting occupational groups share many computer literacy needs: the need to cope with changing office environments, the need for higher-level skills (although the specific principles may differ), and the need to cope with problems of file incompatibilities across computer systems. Prerequisite skills in keyboarding and computer operation, handling of electronic media, managing files, and troubleshooting computer operations are common to all of them. Additionally, computer-aided drafting requires an understanding of complex software environments and complex data bases.

However, while it is possible to identify computer literacy requirements that apply across occupational groups at some level of abstraction, this does not necessarily mean that all these requirements should all be addressed in one course that serves many curricula. The application and implementation of computer-related skills and knowledge is most easily understood in the context of the job task.

APPENDIX B:

COMPUTER SPECIALIST OCCUPATIONS

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THE JOB OF DATA-ENTRY OPERATOR

The importance of the data-entry function is well recognized and documented. Since responsible, accurate entry of data is crucial to the production of timely and correct reports, the data-entry operator plays an important role in the efficient operation of computer-based systems. With data entry and other computer equipment becoming increasingly sophisticated, it is important that data-entry personnel have some formal training.

Duties

An entry-level position for a data-entry operator may carry a variety of titles; therefore it is difficult to identify specific duties. In general, according to The Association for Computing Machinery's (ACM's) Recommendations and Guidelines for a Career Program in Data Entry Operations (Lee, 1981), a data-entry operator should be prepared to

1. Operate data-entry equipment to convert source data into coded form on machine-readable media such as punched cards, paper tapes, magnetic tapes, cassettes, magnetic disks, or diskettes.

2. Verify, in accordance with instructions, the accuracy of data recorded visually and/or mechanically.

3. Monitor and/or operate related peripheral equipment (e.g., a diskette-to-tape converter) to produce desired records.

4. Prepare prescribed record formats and implement their use.

5. Review and organize source documents in preparation for processing.

Job Environment

The environment in which a data-entry operator works varies with the type of industry, geographic area, and other factors. Generally, the operator will work in a facility having either centralized or decentralized equipment. In a centralized configuration, all data-entry devices are in one location (usually close to the central processor). A distributed configuration has devices located at different sites remote from the central processor. The environment in which the operator works may also include word-processing equipment.

The ACM Data Entry Operations Curriculum*

The primary purpose of this curriculum is to produce data-entry operators well prepared to fill entry-level positions in local industries, and to provide them with sufficient background for career growth. This curriculum has been designed to meet the following objectives:

1. To provide technical skills necessary to qualify students for positions in the data entry field.
2. To develop an appreciation of data entry as a career in itself.
3. To provide a base for continued development and education.
4. To improve performance and increase self-esteem.
5. To develop the capability to function in a computer environment.

THE JOB OF COMPUTER OPERATOR

The tasks of a computer operator in mainframe or mini environments are also many and varied. An operator's job contains many non-technical aspects, especially as the operator assumes more responsibility (Kirby, 1981). Furthermore, the functions of an operator in a small organization will likely differ significantly from those working at large installations. However, in all cases the focal point is the operation of the computer and its peripheral equipment.

Researoh here has shown that while there are many different types of programs available, most include the major components of an ACM curriculum model proposed in 1981 (Sweeney et al., 1981). This model is primarily applicable for large systems (mainframe or interactive) and minisystems. An important point to remember is that as corporations are using more personal computers, there are fewer openings for computer operators.

Duties

Since computer-operations jobs vary greatly, it is difficult to identify specific job-related duties. However, any person applying for an entry-level position as a computer operator must be prepared to accept responsibilities such as the following:

*Specific details can be found in Lee et al., 1981.

1. Develop and maintain the knowledge necessary to efficiently operate and recognize malfunctions of the computer and its peripheral components.

2. Develop and maintain sufficient knowledge of operating systems to be able to understand and efficiently act on console messages, prepare job control changes within the job control environment, and operate efficiently with limited supervision in both single and multiple jobstream processing.

3. Develop and maintain a knowledge of software uses, runbook specifications, and job control statements that will facilitate efficient operation.

4. Perform required assemblies, compiles, and tape and disk updates by using appropriate software.

5. Maintain a set of files and supplies for easy access to minimize delay between production runs.

6. When necessary, operate either online or offline data-entry equipment.

Job Environment

Although many configurations of equipment exist, distinctions are most obvious between small and large systems. Small-system configurations typically include a central processing unit (CPU), disk storage, a diskette drive or card reader, a display station, and a printer, whereas large configurations typically include a CPU, direct-access devices (disk, etc.), sequential-mode-access devices (tape), a console, a card reader/punch, and a printer. Both configurations support multiprogramming capabilities, spooling and queuing, central or remote processing, and security devices to protect files and libraries.

The duties of an operator in a small shop, where only a few staff are available, may differ greatly from those in a large shop. The small shop operator is often required to perform a wider range of activities and thus needs to be versatile. The small-system operator needs:

- operations skills
- some data entry skills
- understanding of data control and scheduleing techniques
- some understanding of systems analysis and design
- ability to document
- some understanding of business systems, such as accounting.

The large-system operator is more of a specialist, usually concentrating on one or a small group of functions such as the following:

- console operations
- peripheral equipment operations
- support services
- data control
- scheduling
- data entry
- overseeing other personnel
- documentation
- data communications

The ACM Computer Operations Curriculum*

The ultimate goal of the proposed curriculum is to produce computer operators fully trained to meet the needs of their communities, fully prepared to adapt to changing technologies, and fully aware of their value to industry. To this end, the computer operations curriculum has been designed to meet the following objectives:

1. To provide the technical skills necessary to qualify students for positions in the field of computer operations.

2. To develop an in-depth awareness and appreciation of computer operations as a professional career in itself.

3. To develop the operator's capability to function in different computer environments.

4. To provide a broad base for continued development education.

5. To provide for personal and social growth and the development of communication skills needed to function in a business environment.

Observations

While there is speculation about the extent to which new job openings will continue to occur in these two areas (data-entry and computer operators), they are established fields that have produced many graduates. Nationally recognized curriculum models have been developed which are followed by many post-secondary vocational schools as well as junior colleges. It appears that job

*Specific details about this curriculum can be found in Sweeney, 1981.

opportunities in these areas have leveled off -- that there will be a continuing need for data-entry and computer operators but that the demand has peaked. Therefore, new programs would do well to concentrate on preparing students for different specialized computer-related occupations, such as those discussed in the next section.

EMERGING OCCUPATIONS

The most common major change in the workplace is the addition of computers and attendant "industry-appropriate" technology. This has directly affected the expansion of information systems and the capability of interfacing data processing and word processing. Electronic mail, equipment miniaturization, and computer networking are gaining utility and momentum across industries.

One less obtrusive but equally dynamic (and soon to be more common) change in the workplace is improved automation in telephone systems. Telephone lines are already essential to the concept of telecommunications. Electronic mail and teleconferencing are but two of the more common manifestations of the new "telephone technology." Computer-driven telephone-switching systems have ushered in a myriad of options with pushbutton equipment, and it is anticipated that shopping, banking, and interactive television will be tied to the telphone in the near future (Crohn, 1983).

Implications from these scenarios make it obvious that new roles for office people are being created and that data-entry clerks and computer operators as well as office workers and managers will function much differently -- if they still have jobs.

Robotics, Computer Science, and Repair

By 1990, 80,000 to 100,000 robots will be in use, according to Walter Wiesel, president of Robot Institute of America, a trade association, and PRAB Robots, a manufacturing firm (Education Daily, 1983). However, that prediction can only be accurate if there is a complete turnaround in U.S. economic trends, and if workers are provided with massive retraining efforts to help them cope with the new robot technology.

Other figures are more conservative regarding the robot revolution. Allan Hunt of the Upjohn Institute predicts that 50,000 to 100,000 robots will be in use by the end of this decade (Education Daily, 1983). Hunt feels it is the unskilled and semiliterate workers who will experience the greatest job loss. He adds that 32,000 to 64,000 new jobs will be created in robot manufacturing, supply, engineering, and use. But he also warns that over half the

jobs created by robotics will require two or more years of college-level training. Weisel agrees with Hunt's assessment of on the amount of training necessary for robotic technicians. He says the typical worker in this area will be a person who "understands what the arm is supposed to operate like at the job site."

While community colleges are quick to begin providing the necessary training, they may be overdoing it. Hunt says, "Specifically, a continuation of the expansion of the last year or so in course offerings and enrollments in robotics technician programs on a national scale will very quickly swamp the ability of industry to absorb trained people" (Education Daily, 1983).

According to Peggy Canada, a Cox Cable Communications executive, secondary schools are not adapting quickly enough to this new field. She says, "Robotics and smart machines are going to require chief maintenance technicians who will replace wrenches with computer terminals and trouble shooting programs." But she adds, "Where are the high school courses to begin [to meet] this educational need?" (Education Daily, 1983).

Canada calls for more math and science courses along with traditional skill training, to catch up to the training being offered and provided by industry. In the final analysis, where robotics is concerned, young people need good information on the future of the labor market so as to make informed decisions about the direction of their own job training.

Assessment of the Job Market

For several years concerns have been voiced about the increasing supply of computer operators and data-entry clerks from vocational education programs and the dwindling number of available positions. Furthermore, the people being employed are better educated and are filling more skilled positions (e.g., more programmers and fewer operators). For example, as far back as the late 1970s Hamblen (1980) noted that

> A 1975 survey noted that the number of graduates from the post secondary vocational and associate level programs might soon exceed the number in the labor market. This report assumed that associate degree institutions training students primarily for data entry, operators and clerical data processing positions . . .

And in this same collection of papers Alcorn (1980) stated that

> The makeup of the staff of the computer installation is changing toward a higher percentage of analysts and programmers, and a lower percentage of operators, toward

more full-time and less part-time employees, and toward a slightly better educated staff.

Schools that realized this attempted to shift their emphasis to "newer" computer-based jobs and away from heavy emphasis on computer-operator- and data-entry-level positions. Though they continued to offer these courses (particularly at the post-secondary vocational technical level), many programs were expanding their vision (Rodenstein, 1983).

While starting salaries for systems analysts can go as high as $600 per week, keypunch operators (also known as data-entry clerks) are more likely to receive $227 per week for feeding data into those computers. John Dunn (1983), in writing about computer jobs, says

> Graduates of computer science programs at four-year colleges have few problems finding employment. Those with master's degrees usually can take their pick of several job offers, and the few hundred people who earn computer-related doctorates every year can find many employers eagerly bidding for their services. But many prospective programmers, technicians, systems analysts and computer operators who have completed one- or two-year programs at the nation's community colleges and technical schools are finding they must scramble for work.

Tom Nardone, an economist with the Bureau of Labor Statistics adds, "What people in two-year programs are running into is a tight job market and competition from people in four-year programs" (Dunn, 1983). Part of the problem is the large number of math, business, and engineering graduates going after the same computer-related jobs.

As discussed in the text of this paper, it is clear that different views on how the new technology will affect future job skills are emerging. The first view focuses on the machine as master; the machine will perform the majority of complex tasks. Technology in the workplace will make work easier by reducing physical demands. Therefore, there will be an increase in the number of jobs requiring minimal or low-level skills. An example of this is the user-friendly computer. Many computers now, and more in the future, will be voice-activated, eliminating many of the traditional keyboarding functions. Fewer and simpler skills will be required to manipulate technical machinery and equipment.

The opposing view sees a decrease in the number of jobs requiring low-level skills; as machines become more efficient and productive, they will eliminate many low-level tasks. As a result, many workers will need to upgrade their skills to qualify for higher level, technical occupations. In the future, there will be fewer well-paying, low-skilled manufacturing jobs left to divide among the

many who are poorly prepared. Therefore, "low-skilled and undereducated" most likely means employed or just barely employed.

Recommended Curriculum Sequence for Some Emerging Computer-Related Occupations

The following is a curriculum sequence, for post-secondary students or adults who have been trained in the traditional drafting/machine shop technology. Topics discussed are computer-aided drafting and design (CADD), computer-aided manufacturing (CAM), and robotic control systems (Grieco, 1983).

Computer-aided design and drafting (CADD). This vocational specialization sequence is primarily for students who have acquired sufficient proficiency in conventional drafting methods through vocational training or work experience. After having developed basic knowledge in mathematics and in the operation and programming of microcomputers, students will be provided hands-on experience with microcomputers and associated peripherals such as digitizers and plotters in order to construct mechanical and schematic drawings on the display screen, to create and maintain a drawing library, and to obtain hard copies of the drawings, including sections, subassemblies, and composite drawings.

Computer-aided manufacturing (CAM). There are three general classifications of computer numerical control (CNC) work activities in a machine shop. Qualifications for these positions depend largely on (a) an individual's prior machine shop experience, (b) the mindset needed for writing and testing a computer program, and, finally, (c) lay-out and practical skills in mathematics. The job classifications are machine operator, CNC programmer, and designer/programmer.

The machine operator is usually required to load a prepared CNC tape, to place stock in a machine that is already set up to perform the needed operations, to select the mode to operate, and to shut of the machine when operations are complete. Training required to perform this task includes descriptions of the control panel; the function of the various controls needed to load, execute, and stop the program; and the machine. The operator must re-stock the machine and start the machine cycle again.

Some machine shops employ people who are primarily programmers and who have a good background in algebra, geometry, and trigonometry.

The training required to make them productive in a CNC activity includes a detailed understanding of all controls and indicators. Some training in the traditional non-CNC machining operations is necessary, so that a practical and useful program will be generated. In some instances this is an on-the-job training activity. With a minimum knowledge of machine shop operations, a person could easily

learn the programming functions required to develop high skill and proficiency in operating a given machine.

Expert machinists who are skilled in work set-up, machine operations, and mathematics up to trigonometry will require some specialized training to learn how to program the machine. With sufficient hands-on time with the machine, they can readily become proficient in CNC machine programming and operations.

For the experienced (traditional non-CNC machinist) or post-secondary student, the prerequisites for entering a CAM course should be blueprint reading and traditional machine shop experience. The CAM specialization area will present numerically controlled work piece programming for computer-controlled milling and turning machines. The students will acquire proficiency in menu-driven and "G" code programming, setting-up, operations, testing, and inspection of work pieces from blueprints.

Robotics control systems. This specialization is appropriate for students with sufficient background in electronics and electronic equipment, including (a) electronic devices and circuits, (b) digital concepts and applications, and (c) programmable controllers. This specialization will provide learning experience in the construction, operation, and programming of various robotic devices. Included in the selection of these devices are the concepts of pneumatics, hydraulics, and stepper-motor actuation. Programmable controllers and microprocessors constitute part of the elements of a number of robotic devices.

Recommended curriculum sequence for vocational-technical high school students. For vocational-technical secondary students, a suggested course sequence is as follows:

A. COMPREHENSIVE CADD AND CAM OPTIONS:

(YEAR)	(SUBJECT)
Freshman & Sophomore	1. BASIC MATHEMATICS 2. DRAFTING TECHNOLOGY 3. MACHINE SHOP TECHNOLOGY
Junior	1. TECHNICAL MATH I 2. TECHNICAL MATH II 3. MICROCOMPUTERS AND PROGRAMMING
Senior	1. COMPUTER AIDED DRAFTING 2. COMPUTER AIDED MANUFACTURING

B. ROBOTIC CONTROL SYSTEMS OPTION

Freshman & Sophomore	1. TECHNICAL MATHEMATICS I & II 2. ELECTRONICS FUNDAMENTALS 3. ELECTRONIC DEVICES & CIRCUITS
Junior	1. DIGITAL ELECTRONICS 2. MICROCOMPUTERS & PROGRAMMING
Senior	1. MICROPROCESSORS 2. ROBOTIC SYSTEMS AND CONTROLS

Current core curriculum in computer-based vocational education.

> Many vocational educational teachers are now incorporating the use of the microcomputer into their classrooms. They are using the computer not only as a tool for instruction - as many of their colleagues in Math, English, and Social Studies have begun to do - but as an important object of instruction as well. And in doing so, they are providing their students with computer literacy skills that apply to the students' chosen fields. (Rodenstein, 1973)
>
> In Detroit community colleges have had great difficulty placing graduates of their two-year robotics programs because automakers have been giving short courses on that subject to factory hands. (Time, 1984)
>
> Neither high-technology industries nor high-technology occupations will supply many new jobs during the next decade. (Time, 1984)

We attempted to assess this "expanded view" of vocational education programs by writing to over 30 people who have taught and worked in this area for many years. Among the questions raised were:

- How do computer literacy needs in general differ from computer literacy needs in vocational education programs?
- What training is (will be) offered for computer-specialist jobs, and what will these jobs be? (E.g., data-entry people, CAD/CAM operators, architectural and mechanical technicians, etc.?)
- What programs of this type currently exist, what is being done in these programs, and what data exist regarding the results of the programs?
- What are the highest priority needs for research, development, and dissemination?

Though there were not a large number of responses, those who did respond seemed to agree that the data-entry-level positions were still integral to secondary voc-ed computer-based programs and that a graduate from a two-year program would usually be prepared to be a

computer programmer trainee and/or a computer operator. Typical of the responses were

> . . . there are two-year Data Processing Programs offered through the Business Education departments in high schools/ vocational centers. At the completion of the first year, students are able to obtain entry-level skills as data entry operators. The first year of this program also includes computer literacy. As the completion of the two-year program, students are able to obtain entry-level skills as programmer trainees and computer operators. The three most popular languages taught during the second year are BASIC, COBOL, and RPG. (Professors Anne L. Matthews and Patricia G. Mooky, State of South Carolina, Department of Education, personal correspondence, April, 1984)

> The questions you raise a group of us in this area are now studying with regard to the business data processing programs in the vocational-technical schools. Our best guess at this point is that graduates from high schools are not being hired for jobs above data entry clerk. Firms in our area are hiring their computer operators from the community college data processing programs. To my knowledge, the mechanical technicians are being trained at technical schools (private ones).
>
> As I am sure you realize, the field is changing so rapidly that everything in education in this area is in a state of flux. Studies done four and five years ago are completely out of date. (Professor Adele Schrag, Temple University, College of Education, personal correspondence, April, 1984)

> In conclusion, I would like to add a personal observation on the area of vocational and technical product development: There have been no new technologies of any substance added to the traditional curricula in spite of accelerating technical change within recent history. In fact, the converse appears to be true. As technical development accelerates, the need for integrated or hybrid technologies appears to grow. For example, commonly accepted "high tech" curricula such as robotics is basically an integration of electronic and mechanical tech; while CAD/CAM operators must have a firm grounding in drafting. The very importance of computers and allied digital technology had obviated its separation from technical curricula. (William W. Sprague, South-Western Publishing Company, Industrial Education, personal correspondence, April, 1984)

Typical of the courses that are offered in school systems are those included in the program described by the material submitted by

the State of South Carolina, and one described in a recent article (Adams, 1984):

> An important program goal of the Indianapolis Public School District is to help students become computer literate beyond general computer awareness of programming and languages.

OBSERVATIONS AND CONCLUSIONS

Based on this information, we derived the following observations:

(1) Many secondary as well as most post-secondary vocational education programs include computer-related courses in their curricula. They include the following types:

- A specific course to train computer operators and one to train data-entry clerks. These courses are disappearing slowly from the curricula since the job market is nearly saturated -- especially for computer operators.
- Replacing these courses are others, such as CAD/CAM operators, robotics technicians, and computer programming in all shapes and sizes, but primarily business-oriented -- COBOL, RPG, etc. The market for students with a programming background has become much tighter, however, although "specialist training" programs still place their graduates without much problem.
- There has been a mixture of computer awareness and computer fluency courses -- basically due to a lack of equipment at some schools -- though now most programs provide "hands-on experience (to varying degrees, but most now emphasize fluency).

(2) Some vocational teachers are starting to include micros in their normal modes of instruction. The computer is really seen as a necessary, if only because ubiquitous, tool for numerous vocational education career paths.

(3) Vocational education programs are in close touch with their local/regional business communities and are attempting to meet the needs of the marketplace. They provide training and try to be responsive to the quickly changing face of the job market. Most of them work with advisory committees of local business/labor government leaders to obtain regular input and keep abreast of fluctuations in staffing requirements.

(4) Like other computer-oriented programs, they especially suffer from a lack of qualified personnel to teach them the courses. Many post-secondary programs often find that the courses they have

been teaching are also now outdated because students are coming into the programs having already learned the material in high school. "Getting closer to the equipment" is a theme regularly heard in the hallways of these schools.

(5) There is a trend toward more software/hardware interface problems now that most programs have microcomputers to work with (e.g., for graphics design, industrial robotics, CAD/CAM, architectural drafting, etc.).

(6) Many companies are retraining employees for traditionally "voc ed" positions rather than hiring graduates of vocational education programs (e.g., in data entry and computer equipment).

Though the data are not clear, we feel that young people need to be prepared to face alternative working environments. The factory of the future will comprise emerging technological components of today: flexible manufacturing systems, flexible manufacturing cells, robots, and computers. As the knowledge base continues to expand, the number of traditional jobs will decline and new jobs created will demand greater preparation and sophistication.

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- At Home in the Office: A Guide for the Home Worker

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- Procedures for Conducting a Job Analysis: A Manual for the COMTASK Database
- COMTASK User's Guide

State-of-the-Art Papers:

- The Changing Business Environment: Implications for Vocational Curricula
- Computer Literacy in Vocational Education: Perspectives and Directions
- Computer Software for Vocational Education: Development and Evaluation
- Educating for the Future: The Effects of Some Recent Legislation on Secondary Vocational Education
- The Electronic Cottage
- High Technology in Rural Settings
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- Robots, Jobs, and Education
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