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ABSTRACT

A synthesis of the report, "Microcomputers in Vocational Education: Current and Future Uses," this document identifies and addresses a number of critical issues associated with microcomputer use and offers ideas on explicit ways that the microcomputer is being and can be used for vocational instruction and management. The document contains seven chapters, each one designed to convey information on both the microcomputer's present uses in the vocational classroom and its future possibilities. Chapter I provides some general insights into the issues surrounding the use of this technology by presenting three possible scenarios on ways that the microcomputer may be used in the vocational setting, along with a brief history and definition of the microcomputer. Chapter II investigates the use of the microcomputer in vocational education in light of the changing social and economic needs of our society, while chapters III and IV explore the two most popular applications of the microcomputer in education: computer-assisted instruction (CAI) and computer-managed instruction (CMI). Chapter V presents much of the same information concerning the use of the microcomputer for administrative and management purposes. In chapter VI, future uses of the microcomputer are examined by exploring advanced technological devices that may help improve or modify the ways microcomputers can be used to deliver vocational instruction. Finally, in chapter VII, some of the possible applications of microcomputer technology are summarized, and suggestions on appropriate roles for federal, state, and local policymakers are offered. (KC)

Research & Development Series No. 239A

MICROCOMPUTERS IN VOC ED: A DECISION GUIDE

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1983

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FOREWORD

From every side, today's vocational educators are being inundated with glowing stories of the microcomputer's tremendous potential for both classroom instruction and institutional management tasks. But just what is a microcomputer? What are its advantages and limitations? How is it now being used in vocationally oriented education? What future roles are appropriate for this technology in light of our nation's changing economic structure and labor market characteristics?

This document is a resource and a guide that will help individuals within the vocational community answer such questions. A synthesis of the report "Microcomputers in Vocational Education: Current and Future Uses," this document identifies and addresses a number of critical issues associated with microcomputer use and offers ideas on explicit ways that the microcomputer is being and can be used for vocational instruction and management. Additional information on specific sources of information about microcomputer applications and uses may be found in the companion document *Microcomputer Resources for Voc Ed*.

The National Center is indebted to Dr. James P. Long, who served as project director on the original study, and to Gale Zahniser who is the principal author of this work. Special gratitude is also due Dr. Leonard Nasman, now of the Department of Engineering Graphics of The Ohio State University, who directed the project during its early stages. Sharon L. Fain of the National Center is also recognized for her work in refining and revising the final edition of this document.

Special appreciation is extended to five field-based experts who participated in a modified Delphi poll during the initial investigative effort. These individuals were Leroy Finkel of the San Mateo Education Resources Center, Redwood City, CA; James Poirot of the Computer Science Department at North Texas State University, Denton, TX; Richard Ricketts, Managing Editor of *The Computing Teacher* at the University of Oregon, Eugene, OR; Jeffrey Sarnoff, Research Scientist at Atari, Sunnyvale, CA; and Kenneth Talbert, Coordinator of Business Education at Rosemount High School, Rosemount, MN.

Special notice is also drawn to the excellent contributions provided by those who reviewed and critiqued the original manuscript. These individuals were Dr. Bernard M. Ferreri, Associate Vice-Chancellor for Career and Manpower at the City Colleges of Chicago; Dr. Asahi T. Oshima, Career and Vocational Education Specialist in the Boulder, Colorado School District, Boulder, CO; Dr. Byrl Shoemaker, retired State Director of Vocational Education, Columbus, OH; and Connie Faddis and Dr. Stephen Franchak, National Center staff members.

Appreciation is also extended to the Field Services staff members who provided the editorial review of this report. Also, special thanks are accorded to Carolyn Goodrich, Margaret Barbee, Beverly Haynes, and Vicki Gaines for their exemplary assistance with typing and manuscript preparation.

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EXECUTIVE SUMMARY

Today, microcomputers are all around us. These small, inexpensive machines are being used by game players, business executives, owners of small businesses, homemakers, secretaries, teachers, and many others. This report examines what vocational educators are currently doing with microcomputers and summarizes what can be done and should be done with them in vocational education settings in the future.

The contents of this report were derived primarily from two sources of information. One source was the opinions and perceptions of field-based experts knowledgeable about both microcomputer technology and the application of that technology to technical and vocational education. Five individuals, selected for their knowledge and work in the field, were asked to comment upon the variety of ways that a microcomputer can assist vocational educators, the issues and concerns that will confront vocational leaders as they adopt this technology, and the appropriate roles for private and public sector groups in helping vocational education respond to this technology.

The second source of information was a comprehensive review of the literature related to microcomputers in vocational education. Computer searches were made of several databases and specialized manual searches of vocational and computer-related technical journals were completed. In this way, the state of the art of microcomputer applications for vocational and technical education was ascertained. Additionally, major issues and questions that vocational planners, leaders, administrators, and instructors must confront and resolve were identified in the literature.

The document contains seven specific chapters, each one designed to convey information on both the microcomputer's present uses in the vocational classroom and its future possibilities. Chapter 1 provides some general insights into the issues surrounding the use of this technology by presenting three possible scenarios on ways that the microcomputer may be used in the vocational setting. A brief history and definition of the microcomputer are also included to give the reader a clear understanding of just what this technology encompasses.

Chapter 2 investigates the use of the microcomputer in vocational education in light of the changing social and economic needs of our society. In addition, discussions on ways to change vocational curricula in order to utilize this technogy are presented, along with examples of some current and proposed changes.

Chapters 3 and 4 respectively explore what are perhaps the two most "popular" applications of the microcomputer in education: computer-assisted instruction (CAI) and computer-managed instruction (CMI). For each of these applications, the document explores such issues as the advantages and disadvantages of the application, ways that the application may be implemented in the vocational institution, and the general effectiveness of the application. Chapter 5 presents much of the same information in regard to the use of the microcomputer for administrative and management purposes.

Chapter 6 takes a look "beyond the microcomputer" by exploring advanced technological devices that may help improve or modify the ways microcomputers can be used to deliver vocational instruction. Finally, in Chapter 7, some of the possible applications of microcomputer technology are summarized, and suggestions on appropriate roles for federal, state, and local policymakers are offered. A glossary of microcomputer terminology is included as an appendix to assist the reader in understanding current microcomputer "jargon."

With the variety of information and the many examples of microcomputer applications presented in the document, it is hoped that the reader will gain a clearer idea of both where vocational education stands in terms of microcomputer use, and where it might be headed in the future.

CHAPTER I: INTRODUCTION

Barely twenty years ago, machine-delivered instruction was something you discussed at a science fiction convention—not at a faculty meeting. Today, thanks to incredible advances in both engineering and electronics, the small, versatile machines known as "microcomputers" are readily gaining acceptance as both instructional and administrative tools in school systems across the United States. But just what is a microcomputer? What will its impact be on the schools and classrooms of the future? How will it affect both the vocational curriculum and the delivery of instruction? These are just a few of the questions now confronting today's educators and administrators—questions that must be answered before the microcomputer can assume a realistic and functional role in the vocational institution.

In recognition of this need for knowledge, this document was prepared to serve as a comprehensive reference manual for the vocational educator or administrator interested in or already grappling with the issues of microcomputer technology. To give such personnel a brief overview of both the contents of this report and the technology it explores, this chapter will highlight the research effort behind the original study, the general issues surrounding the use of microcomputers in the classroom, and a history and definition of the microcomputer.

Purpose and Methodology of the Study

Intended for use by vocational education planners, researchers, state and local administrators, and classroom instructors who are interested in microcomputers, *Microcomputers in Voc Ed: A Decision Guide* is the result of a two-phase research effort carried out by staff of the National Center for Research in Vocational Education. During the first phase, searches of several databases and specialized searches of vocational and computer-related technical journals were conducted in order to ascertain the state of the art in microcomputer applications for vocational and technical education. In addition, the major issues and questions that vocational planners, leaders, administrators, and instructors must confront and resolve were identified.

The second phase of the project focused on a survey of the opinions and perceptions of five field-based experts knowledgable about both microcomputer technology and its application to technical and vocational education. Selected for their knowledge and work in the field, each individual was asked to comment upon the variety of ways that microcomputers can assist vocational educators, the issues and concerns that will confront vocational leaders as they adopt this technology, and the appropriate roles for private and public sector groups in helping vocational education respond to this technology. These persons included—

- Leroy Finkel, San Mateo Education Resource Center, Redwood City, California;
- James Poirot, North Texas State University Computer Science Department, Denton, Texas;
- Richard Ricketts, Managing Editor of *The Computing Teacher*, University of Oregon, Eugene, Oregon;

- Jeffrey Sarnoff, Research Scientist, Atari Incorporated, Sunnyvale, California; and

- Kenneth Talbert, Coordinator of Business Education, Rosemount High School, Rosemount, Minnesota.

With such information at hand, it is hoped that the reader of this decision guide will come away from the document with (1) a better understanding of the microcomputer itself, (2) a clearer idea of the complexity surrounding its effective implementation in vocational education, and (3) a sharper picture of where vocational educators are and can be headed in relation to this emerging technology.

An Overview of the Issues

In less than a decade, microcomputers have left the exclusive domain of the electronics research laboratories to become common devices that are familiar to most people. If properly managed and used, these small, inexpensive computers carry with them a capability that has the potential to change significantly the way we live, work, and receive our education. As yet, however, there is no firm consensus about the specific, lasting changes that will occur in education as a result of the microcomputer's presence.

Many people in vocational education suspect (and perhaps hope) that the microcomputer will bring with it a total revolution in the delivery of vocational education instruction. The expectation of these individuals is that microcomputer technology will somehow enable schools to offer more high-quality, up-to-date programs at the same time costs are kept to a minimum.

Obviously, this new technological development has more implications for all aspects of vocational education than did many earlier audiovisual instructional aids, such as radio, slides, filmstrips, television, and videotapes. All of these earlier developments have been used to improve instruction, and excellent examples of their use can be identified—yet none of them have quite lived up to original expectations. Neither have they been used as broadly in education as they might have been.

Some of the reasons the earlier audiovisual devices did not contribute to improvement of instruction as much as expected are as follows:

- Cost of equipment

- Cost and availability of software (films, slides, tapes, television lessons)

- Inadequate or disorganized courses of study

- Inadequate teacher preparation

- Inadequate servicing of equipment

- Lack of adequate released time for instructors to develop material applicable to the instructional program

Some of these same reasons will also affect how microcomputers will be used in education.

Present-Day Views of the Future

Thus far, at least three different scenarios have been predicted regarding changes that can be expected in the vocational education delivery system as a result of microcomputer technology.

First is the "optimistic scenario." According to this view, microcomputers, computer-managed instruction, computer-assisted instruction, and similar electronic devices and systems will replace teachers, and computer-based simulators will replace shops and labs. The quality of instruction will be very high because only the best presentation and delivery methods will be used. Curriculum materials will be kept up-to-date since most of them will be computer-based, not print-based. Schools will be able to offer all possible curricula even if only one student is interested since instruction will be completely individualized. All this will somehow be done at a reasonable cost.

There is also a "pessimistic" scenario. Its proponents believe that today's new instructional technology will become only a passing fad like Skinner's teaching machine, programmed learning, or opaque projecters. Education will plod along with only a minimal and occasional use of high-technology systems. Microcomputers, videodiscs, and such devices will be used only in games or in entertainment of other kinds, but not in school-based or home-based education. The microcomputer is nothing more than a fantastic solution crying out for an educational problem to solve, but that problem will never be found.

Finally, there is a "realistic" scenario. Arriving at their conclusions by logically extrapolating current trends and developments, the proponents of this viewpoint feel that schools will make it standard practice to use microcomputers, videodiscs, computer-assisted instruction, computer-managed instruction, and other high-technology systems for four specific types of activities: (1) drill and practice, (2) tutorial dialog, (3) simulation/demonstration/game playing/creating, and (4) the development of computer literacy.

Clearly, the "optimistic" scenario is extreme. It is far too ambitious and discounts many nontechnological realities that will impede a complete takeover of the nation's schools by microcomputers. Among such realities are that it will be very expensive to develop and implement good instructional uses of microcomputers and that microcomputers will never replace teachers. This latter opinion has been adopted in light of the belief that teachers must remain in the schools, as they provide a vitally needed "baby-sitting" function along with their teaching. The importance of teachers in this regard is further strengthened by recent growth in the number of single-parent families and families in which both parents are working—trends that will demand that our schools continue to employ approximately the same ratio of teachers to students.

In contrast, the "pessimistic" scenario is not ambitious enough, as it ignores the fact that microcomputers are not simply a passing fad. Clearly, microcomputers will not be absent from our schools at a time when so many children already have them in their homes. Furthermore, almost every occupation today is being influenced in some way by the microcomputer; thus computer literacy, awareness, and skill training must be among the survival skills that are taught to our students.

The third scenario, consequently, is the one most likely to come true. Microcomputer technology will undoubtedly change the *way* teachers teach, but it will not replace teachers—even partially. Furthermore, microcomputers will also affect and influence both curriculum content and vocational education delivery methods. Perhaps more than anything else, these trends point to the need not only for careful planning in the adoption of microcomputer technology, but also for the recognition of the microcomputer as a teaching tool—not as a teacher substitute. Such changes and responses will form the focus of succeeding chapters in this document. Yet before exploring the potential impact of these machines, it is wise to obtain an understanding of the technology's history and development. Such information will be presented in the remainder of this chapter.

The Microcomputer: A Brief Background

History

The microcomputer had its beginning in the early 1970s when the California-based company, Intel, a designer and manufacturer of large-scale integrated circuits, determined that there might be a market for a general purpose microprocessor chip that it had developed. By integrating this chip with various electromechanical devices, Intel discovered that the chip could be adapted to a wide variety of uses ranging from machine tool controllers and medical equipment to terminals for airline reservations.

Before long, a number of gifted researchers in the electronics industry were integrating microprocessor chips with electronic memory boards, input and output devices such as keyboards, and video display tubes and monitors. This assembly of components is what has become known today as the microcomputer.

At first, microcomputers were kits of individual components that the purchaser had to assemble. Yet despite the inconvenience of their construction, the rapid sale of these kits demonstrated that there was a viable market for the microcomputer. As a result, several companies began to introduce low-priced, fully constructed units. In the fall of 1977, Radio Shack announced the availability of TRS80 Model I for $600.00. There is a rumor in computer circles that the Tandy Corporation, the parent company of Radio Shack, projected sales of 10,000 units for the first year. However, estimates are that first year sales surpassed the 100,000 mark. With a lucrative market thus established, microcomputers such as the Commodore PET and the Apple II were released for sale, and the "computer revolution" was underway.

The earliest microcomputers had very limited memory space and, for the most part, were not taken seriously by individuals in the traditional computer-related disciplines of data processing and computer science. However, advances in microelectronics led to the creation of microcomputers with expanded memory space that still were low-priced. As a result, these small machines began to present a serious challenge to the larger mainframe and minicomputers. Although the microcomputer has been accepted by the general public for several years, it was not until the introduction of the IBM Personal Computer that many data processing personnel were ready to pay serious attention to the capabilities of the microcomputer.

Definition

As the capabilities and memory capacity of microcomputers have rapidly expanded, the distinction between them and the larger mainframe and minicomputers has blurred.

For the purpose of this document, the commonly accepted practice of distinguishing computers according to price has been adopted. Typically, computers that cost more than

$100,000 are considered to be the mainframes; those costing between $10,000 and $100,000 are minicomputers; and those costing less than $10,000 are the microcomputers. It must be kept in mind that although all computers (and some hand-held calculators) share a variety of common features and capabilities, several current brands of microcomputers have capabilities not available on minis or even on some mainframes. Another notable distinction between the different classes of computers is that most minis and mainframes will usually have more memory capacity than microcomputers. This is an important distinction to make because certain applications in vocational education may require large amounts of memory space.

A typical microcomputer installation will have a computer console with a typewriter-style keyboard, a video display (often a television receiver), and an external memory device (a tape cassette player or a disk drive). Most computer consoles will contain some software—computer programs—supplied by the manufacturer as ROM (read only memory) and from 16,000 to 60,000 bytes of RAM (random access memory). To put these characteristics in perspective, in the mid-1960s the IBM 1130 computer could be leased for $1,500 per month and had 16,000 bytes of random access memory and no read only memory. As of the fall of 1982, microcomputers with 16,000 bytes of random access memory and 18,000 bytes of read only memory could be purchased for less than $300.

Although most microcomputer keyboards are similar, many have been designed with specialized applications in mind. For example, those designed for scientific or technical work will have extra keys that permit specialized calculations, while those designed for word processing will have special keys for word processing control commands. Those selecting microcomputers for such vocational subject areas as accounting or electronics may need to consider carefully the types of keyboards they need when purchasing a microcomputer; instructors may need these specialized keyboards as opposed to the general purpose consoles that come with most microcomputers.

There are two types of video display units for microcomputers—the television receiver and the monitor. Both of these devices display the information as it is entered into or yielded by the microcomputer. Also, both may display information in color or in monochromatic tones. Most of the popular microcomputers will work with either type of display, but certain applications may require the use of one or the other. Monitors typically have higher resolutions (resulting in sharper images) and are usually more expensive than television receivers.

The two most common external memory devices associated with microcomputers are cassette tape recorders and floppy disk storage units. Cassette recorders selling for under $100 are less expensive than the floppy disk unit, and some microcomputers can use a standard portable cassette recorder. Disk-driven storage units that use five-and-one-fourth-inch floppy disks are the most common, although some eight-inch drives are available. The cost of the disk drives ranges from $400 to $800 each, and they use removable disks. The advantage of the disk drive is that it holds a large volume of information that can be accessed and fed quickly and randomly into the microcomputer's memory. Hard disk drives are also available for microcomputers. These units allow for storage of up to twenty million bytes of data and are currently priced at about $3,000.

Costs of microcomputers vary. The typical microcomputer installation consisting of a keyboard console with 48K random access memory, a video display, and a single disk drive currently costs between $1,500 and $3,000. In contrast, the Minnesota Computer Consortium has an arrangement (in 1982) with Atari to supply an Atari 400 with 16K of RAM, a disk drive, and a black and white television receiver to schools for less than $600. These price estimates are for hardware only. Software packages for educational use may cost from fifteen dollars to several hundred dollars each.

CHAPTER II: THE MICROCOMPUTER AND THE INSTRUCTIONAL CONTENT OF VOCATIONAL EDUCATION

Vocational education has two primary goals. The first, most often cited is the transference of skills to a student to enable that person to get a meaningful job. The second, more abstract goal is to imbue the student with a sense of self-worth and personal satisfaction. Personal achievement is often the key to reaching both of these goals. Such achievement can be found through interaction with microcomputers, as the machines can do a respectable job of increasing knowledge in a specific area and an excellent job of transferring understanding about specific processes.

Clearly, the first step in understanding the microcomputer's future role in vocational education is to develop an understanding of how this technology will affect the structure and content of what we now know as vocational education. Therefore, in this chapter we will be examining the need to respond to microcomputer technology, the changing content of occupations, methods of changing the vocational curriculum, and examples of current and proposed changes in the vocational curriculum.

The Need to Respond to Microcomputer Technology

Perhaps the first observation that must be made regarding the microcomputer's role in education is that the use of this technology in general or academic education may indeed be quite different from its use in vocational education. Even now, many academic educators view the microcomputer as useful and necessary for teaching specialized math, science, or computer programming courses, but not necessary for other disciplines. Vocational education, however, will be able to adopt such an attitude only at the risk of producing students who are ill equipped for the employment market. Thus sooner or later, every school that chooses to offer vocational training must not only confront and deal with this new technology but also modify the instructional content of its program offerings to reflect the new technology.

Shane (1982) reinforces the need for such response by discussing the various ways in which he sees the vocational institution changing because of the microcomputer. He notes, for example, that vocational education will eventually be cast into a broader context of lifelong learning—a context that will include training not only for young people but also for those workers displaced by automation and robotics. More specifically, he feels that

> as the computer changes the work place, schools will find themselves pressured to modify vocational education and guidance programs to make them respond more rapidly to change. Lifelong education—including vocational education or "retrofitting" for those replaced by robots—for mature (over 30) and senior (over 55 or 50) learners seems likely to open new, highly useful social roles for the schools. (p. 305)

In regard to the integration of the microcomputer into the instructional environment of our schools, Molnar (1981) feels that the most important challenge now facing education is to find an answer to the question, "What are the capabilities of the computer?" He cautions that unless this question is answered via the instructional content offered in schools, the simple lack of computer knowledge will make people just as functionally illiterate as if they could not read, write, or do arithmetic.

The Changing Content of Occupations

There is a body of literature that suggests that the instructional content of vocational education needs to be responsive to microcomputer technology in order to prepare all students (including adults in need of retraining) for the job market. For example, in summarizing a statewide survey of microcomputer activity in Montana schools, Dolan (1982) writes:

> As in the case of districts nationally, the major use of computers in Montana appears in mathematics and programming, with a relative lack of computer use in business education. This area trains a great number of students who enter the working world immediately after graduation. In that world, students face word processors, computerized accounting systems, and electronic information exchanges. If we are to train students so that they can compete for entry into the job market, we must see rapid change in this area. (p. 58)

Other authors suggest that personnel in our nation's education and training systems need to start developing microcomputer-based instructional content and curriculum now in order to meet the demands of the new job market that is slowly evolving under the influence of the microprocessor and microchip. Osborne ("Will Your Job Exist in 2005?" 1980) suggests that the work force of the future will have to be both intelligent and highly trained—thus there is already a desperate need for instructors who are capable of using "high-technology" educational media and techniques. Such instructors, he feels, will be needed in our industries as well as our schools.

Similarly, Cetron and O'Toole (1982) suggest that in order to meet the demands of the employment market of the 1990s, an extensive update of our current training and educational programs will be required. In discussing this issue, they stress the role of vocationally oriented education, as many of the jobs that are appearing will require less than a four-year college degree. They also emphasize the importance of this type of training in meeting the occupational needs of older workers.

Research that actually posits what the overall effect of microelectronics technology will be on the employment market of the late 1980s and early 1990s is divided on the issue of whether there will be a net gain or loss in employment. Cetron and O'Toole (1982), for example, are fairly optimistic about the ability of the new technology not only to create new jobs, but also to absorb the large number of older workers who will have been retrained for new occupations. Others, however, cite instances where job losses have already occurred because of technological advances, and say that even greater reductions will follow. Perhaps the following summary statements, taken from a series of three unrelated articles in separate issues of the *Social and Labour Bulletin*, best convey current viewpoints on both sides:

- The overall employment impact of microelectronic technology (and microprocessors) will depend on whether the technology is used as a means of expanding output or as a means of cutting labor costs ("Employment Impact of New Technology" 1980).

- The new technology (i.e., the microelectronics revolution) has already led to a job loss in certain key industries and services in Western Europe (e.g., the manufacture of watches, cash registers, office equipment, and telecommunications equipment). There are some indications that jobs traditionally held by women (clerical positions) will be affected and that work place polarizations may result between skilled/semiskilled workers on one side and highly skilled technical staff on the other ("The Impact of Microelectronics" 1979).

- Especially for clerical-related jobs, the full impact on employment is still ten to fifteen years away. There is time, consequently, to utilize the educational and training systems to assist with changes that microcomputers will require. However, proper planning will be needed if this is to occur ("How Far Away is the Electronic Home Office?" 1980).

- The actual impact will vary for different economic sectors, with some benefitting and other losing. One of the primary vehicles for redressing the inequality and helping all individuals adjust to the change is the training and educational system. Training organizations need to relate their efforts more closely to the skill requirements of microelectronic technology, and they need to pay special attention to the plight of the unskilled worker ("Employment Impact" 1980; "The Impact of" 1979; "How Far Away?" 1980).

Changing the Vocational Curriculum

From current evidence, there can be no doubt that the vocational education community should and must begin restructuring some of its curriculum offerings to incorporate the use of the microcomputer. But is there one "best" way to accomplish this task? Several authors suggest a three-step approach that includes (1) the development of computer literacy, (2) the modification of existing vocational course content, and (3) development of the ability to use and operate a microcomputer. Each of these activities will be explored in the following sections.

Computer Literacy

While there is a substantial amount of disagreement among experts as to exactly what constitutes computer literacy, nearly all such persons agree that current and future students need more than a casual acquaintance with computers. Molnar (1981), for example, actually proposes that computer literacy be considered just as important as the "basic" skills of reading, writing, and math computation:

> Our society is growing more and more complex. The information explosion has created a discontinuity in the nature of our education needs. Many feel that we should reduce the amount of science taught and instead teach more basic skills. However, the computer is ideal for dealing with complexity . . . . [such] difficulty is not inherent in the subject matter, but in our ability to cope with it . . . . We should redefine what are "basics" in an informational society, and move ahead, not back, to basics. (p. 18)

Other authors do not go so far as to suggest that computer literacy should become a required basic skill, but do recommend that every student (especially those in vocational courses) have some computing background. Uthe (1982a), for example, calls for every vocational student to be given computer literacy training. Like many other authors, she feels that the low cost of today's microcomputers places access to computers within easy reach of all students and teachers and that a failure to provide some form of computer literacy to vocational students will handicap them in the employment market.

To further complicate the computer literacy issue, there is as yet no standard definition of what should be included in a computer literacy course. However, Brumbaugh (1980-1981) notes that as the need for computer literacy becomes increasingly critical, "Every person associated with the field of instructional computing should have a definition of computer literacy." He also calls for the development of computer literacy materials that do not require users to have prior computer knowledge and experience. By developing such materials and offering them to community residents and teachers as well as students, he says, a national goal of computer literacy can easily be attained.

Modifying Existing Vocational Course Content

As noted previously, the second way in which the vocational curriculum must change is through the creation of course materials for each individual occupational program area that reflect microcomputer and microprocessor technology. In this regard, the work of Uthe (1982a) provides a number of examples of possible changes in instructional content for three specific occupational areas: trade and industrial education, agricultural education, and marketing and distributive education.

In the trade and industry area, Uthe expresses the idea that current program curricula should be updated to include (1) electronic training in the design of new machines and the service requirements of existing equipment and (2) training in the operation of machines used in computer-aided design (CAD) or computer-assisted manufacturing (CAM). For agricultural programs, she calls attention to the use of simulations relating to crop rotation analysis, herd improvement records, budget projections, and farm accounting. She mentions the AGNET system as an example of efforts to bring farm news and computer programs for product analysis to local farms and schools. For marketing and distributive education programs, she says students must be taught to operate point-of-sale terminals as well as to understand the types of records that result from the terminals—inventory records, sales analyses, and accounting and credit records. Even more important, she feels, is the development of simulators on the effect of increased sales and/or expenses so that marketing and decision-making skills can be developed.

In regard to business and office education, Uthe notes that programs in this area should require accounting students to use the microcomputer for homework assignments because this would drastically reduce the amount of time needed to calculate figures for a worksheet. As a good general ledger software program can prepare the entire worksheet in a matter of seconds, she says, more instructional time can thus be spent on studying relationships and determining profitability. In addition, students will probably be able to advance more rapidly to "what if?" problems, or simulations about market trends, cost recovery programs, and other decision-making problems.

Noting that the home of the future will incorporate the computer in such tasks as shopping, home management, cooking and nutritional management, and personal finance and budgeting, Uthe also feels that home economics programs must prepare homemakers for the electronic home. All these applications, she feels, should be incorporated into the curriculum now in order to prepare homemakers for the future.

Admittedly, with today's fast rates of technological and industrial change, the process of incorporating such course content into the vocational curriculum could easily become a risky business. To prevent the initiation of outdated concepts and practices, therefore, it is suggested that instructors utilize as many varied sources of information as they possibly can. The first step in this process might be for the vocational instructor to read trade journals, industrial publications, and other technical materials in order to gain a national perspective on microcomputer applications. (For suggested publications, see the companion document *Microcomputer Resources for Voc Ed.*)

Instructors will also need to begin monitoring the microcomputer applications that local business and industry are developing—possibly through increased use of local advisory councils. Merchant (1982) especially credits the use of employer advisory councils for successful curriculum changes.

Learning to Use a Microcomputer

The lack of widespread familiarity with computers among instructors and staff is often cited as the primary factor that impedes the implementation of changes that this technology might make in the educational setting. For example, Stevens (1981) and Huntington (1981) state that even though the microcomputer places computer technology within the reach of educators, most of them are, in fact, unprepared to integrate the technology into their regular curriculum effectively. These and other authors do not merely say that instructors need to learn how to operate a computer or understand how the computer itself works. Rather, they suggest that the microcomputer offers many new instructional options to the instructor and is capable of changing the content of instructional materials that are offered to students. However, they indicate that teachers need advice and training about *how to use* the computer to the best instructional advantage and *how to apply* it to classroom functions in coordination with other teaching tools. In essence, there is a need to train teachers how to teach by using microcomputers, not just how to teach others to use microcomputers.

What is critically needed is inservice training that is individualized for each program area. Ideally, such training would focus on how a microcomputer can and should be applied to a specific program area, and how it can be integrated into an instructor's overall teaching patterns. For example, instructors from different occupational areas may need to learn how to choose hardware systems that most readily meet their instructional needs. Nasman (1982) notes that business and agricultural instructors may need systems that are "user friendly," while electronics instructors will need to choose systems that permit a demonstration of the computer's operation. Inservice training for some program areas (e.g. business and accounting) will need to focus more on commercial software selection, while others may need to focus on the development and design of original software. Similarly, depending on the program area, inservice training may or may not need to include—

- programming,
- knowledge about how to plan for the integration and application of the microcomputer in the specific instructional programs, and
- methods for identifying and locating instructional resources.

Beyond such technical instruction, teachers will also need to develop an understanding of the sociological and institutional changes that may occur as a result of the microcomputer's implementation in the classroom. In this regard, specialized inservice training is needed in two areas: the changing role of the instructor and methods for planning computer-based instruction.

The changing role of the instructor. At this point in time, the complete infusion of the microcomputer into the curriculum of a given program cannot and will not be a spontaneous process. This is because the microcomputer has not been in use long enough for anyone to know its ultimate impact on such areas as course content, student-teacher relationships, teacher roles and status, and student motivation and rates of learning. A number of articles have already been written, however, on some of the changes that teachers can expect in both the short and the long term.

Steffin (1982a), for example, feels that the role of the teacher will change from that of a "broadcaster" or "provider" of instruction to that of a "manager" of instruction. He makes this statement based on his perceptions of how the learning process may change into a situation where the student may initially gain a large part of his or her instruction in a nonclassroom environment. Later, the student will come under the direction of an instructor who will guide student interaction and dialog and who will also provide general support for the student's overall intellectual development.

Spencer and Baskin (1981) suggest that teachers will be cast more as coparticipants with students, parents, and others in the learning process. Similarly, Sheingold (1981) feels that the instructor will become a "buff"—someone who not only is knowledgeable about and interested in the microcomputer, but who spreads its use by encouraging and teaching others about its use. During this "transfer" process, she says, student experts may also emerge and their need for more courses and better-trained teachers can pose some problems.

Authors frequently mention the fact that instructors often resist the infusion of the microcomputer into the classroom because they fear that the computer may ultimately replace them. However, many if not most authors say the opposite will occur. For example, Herriott (1982) says that instead of losing a job, a good teacher will gain a freedom of action when the computer is used. He writes that instructors will be able to avoid many of the petty duties often associated with the profession and instead be transferred into challenging activities. From his perspective, when a computer becomes an integrated part of the instructional content and delivery of a course, the instructor can impart information on a one-to-one basis; provide imbedded remedial action; offer enrichment material; keep accurate track of student progress; allow the student to progress at an individual pace; provide video and audio support; and provide a massive information retrieval base. He also notes that no computer will ever be able to usurp the teacher's most valuable asset: the ability to make judgments on matters of instructional taste and quality and to steer students in the most appropriate educational direction.

Similarly, in testimony before the Congressional Committee on Science and Technology, Melmed and Sticht (1978) said that while the role of the teacher will not diminish, it will definitely change. In their opinion, the teacher will become more of a "sharing person" who, along with others, will be responsible for the students' learning experiences. In addition, while teachers will continue to support basic skills, they will also give special attention to ways in which these skills relate to new media and technologies.

Methods for planning microcomputer-based instruction. Along with the changing role and status of teachers will come new opportunities for the use of "creative" teaching methods. However, to take advantage of these opportunities teachers will first need to undertake some specific and careful planning.

In this regard, an instructor must first become aware of how and when a microcomputer can or should be used. In the article "Will Your Job Exist in 2005?" Osborne (1980) notes that a microcomputer is certainly not applicable to all instructional tasks. Instead, its most appropriate use is for tasks that can be explicitly defined. For example, the microcomputer can be used to individualize instruction because it can be programmed to provide immediate feedback for wrong answers and to advance a student automatically to more difficult material when satisfactory competency is demonstrated.

Other authors, such as Lee (1982), suggest that the microcomputer is appropriate for tasks requiring a high degree of visualization, but is unappropriate for the delivery of reading material or for the teaching of psychomotor skills. Once the appropriate tasks are identified, instructors need to plan carefully their instructional goals and objectives. Then they will need to analyze the teaching techniques they plan to use to reach those goals. Kosel (1980) urges instructors to remember that the "microcomputer should be viewed as a teaching tool and used in the curriculum when it can create new learning experiences or present a fresh and useful approach to learning. . . .(p. 104)" A microcomputer is not an effective replacement for a task (e.g., a laboratory experiment) that students can do for themselves. However, a computer can be used to make ordinary drill problems more interesting (because problems can be randomized), and routine computational problems can be performed more quickly—thus allowing students to examine higher-level concepts. Similarly, the simulation abilities of a microcomputer can be used to help students study or work with phenomena that in real life would be beyond them because of factors of time, cost, or physical danger. Kosel also observes that the sound, color, and graphics capabilities of the microcomputer can make the learning process more exciting and inviting.

Examples of Curriculum Changes

There is a body of literature indicating that vocational education instructors and administrators are already seeing the need to develop course content and instructional practices that reflect microcomputer technology. Some of the literature is written by those who, like Uthe (1982b), are suggesting ways in which instructional content can or should change. Other references describe current applications and situations where instructional content is already being changed. Both current and proposed changes will be highlighted in the following sections.

Current Changes

Merchant (1982) describes a course called "Desk Top Computers" that is now in operation at Washington Community College in Spokane. The course was developed in response to demands from local businesses that students be familiar with computer technology. These same employers, in turn, advised the school about the type of hands-on instruction students need. The course teaches students to use a computer through exercises in flowcharting, simple basic programming, data entry and correction, and data retrieval. The course is competency-based, is geared for open-entry/open-exit enrollment, and allows students to work at their own rate.

A similar program is also being offered at Santa Fe Community College in Gainesville, Florida. Known as "Industrial Options for the Electronics Technology Curriculum," the course allows students to become technicians capable of working with microcomputers and using them as tools in problem-solving situations. The curriculum requires three credits in microcomputer programming and three in microcomputer applications. A microcomputer laboratory that allows students to study the inner workings of a computer has also been established. The program's instructor, Jack Kennedy, credits an active employer advisory group with a large part of the program's success.

Bristol (1982) describes a computer literacy program at Lyons Township High School in La Grange, Illinois. The program was developed around four critical computer areas: literacy, competency, specialty, and CAI. Through the program, computer literacy instruction is offered to the entire staff, who then become involved in the development of instructional modules and computer literacy training for students. During the program, teachers with subject expertise in home economics, industrial arts, and other vocational and academic specialties identify applications of microcomputers to their own courses. Those individuals then work with special coordinators who have some experience with computer use and applications. These coordinators review the teachers' suggested applications, identify those that are most adaptable for instructional use, and work with technical programmers who develop the microcomputer software for the teachers to use in their classes.

Two authors have reported how they use microcomputers as part of their instruction in accounting In describing her utilization of microcomputers for accounting classes at the Billings Vocational Technical Center (a postsecondary school in Billings, Montana), Halvorsen (1982) notes that a number of prepared software programs are already available for teaching accounting procedures. Furthermore, she feels that since accounting students will eventually be required to operate microcomputers in the work place, it is important that their in-school training incorporate microcomputer applications. The Billings program includes such instructional components as familiarity with hardware and software, keyboarding, data entry, and formatting of desired financial records.

Miller (1982) reports that she uses microcomputers in the business department at Southeast Guilford High School in Greensboro, North Carolina. The program, one of nine throughout North Carolina, is a pilot effort through which students gain hands-on experience in applying accounting principles they have learned in class (e.g., accounts receivable and payable, general ledger, payroll, and inventory) to the microcomputer through various software programs. In the near future, students will also be taught the BASIC programming language and flowcharting.

In the area of *agriculture*, Eigmy and Fuller (1980) note that the microcomputer is one of today's most effective tools for farm management education. This is because it has the ability to keep daily farm records and accounts, serve as an electronic filing cabinet for storing crop and livestock records, and analyze records on any given day rather than at the end of a month or year. According to their report, microcomputers are now being used in combination with programmable calculators and a mainframe, on-line terminal for instruction of a farm management course at the University of Minnesota's Technical College at Waseca.

Dean (1982) also focuses on the use of the microcomputer in the vocational agricultural education classroom. Although his article is primarily concerned with the creation and development of software to be used in the instructional process, Dean also touches on curriculum content that should be offered to students in agricultural education classes. He explores in some detail the efforts underway in his state to—

- develop appropriate courseware offerings for the microcomputer;

- provide instructional guidance and instruction to instructors who will use microcomputers in the state's secondary and adult education classes; and

- determine the computer-related skills that students most need in an agricultural curriculum.

A slightly different instructional approach (one that utilizes equipment controlled not by microcomputers but by microprocessor chips) is described by Kerfoot (1981). He discusses the benefits that students in the Instrument Analysis Program at Charles County Community College in Maryland receive from using a device called a "video output atomic spectrophotometer." In contrasting the instruction of these students with that of students who receive instruction on a similar instrument that is not controlled by the microprocessor, Kerfoot notes that the atomic spectrophotometer not only assists students with computational tasks, but also functions as a powerful educational tool by simulating calibration curves and providing immediate data feedback.

Proposed Changes

Beamer (1980) provides an excellent insight into the future need for microcomputers in the vocational *agriculture* curriculum:

> Agriculture has changed from what is commonly referred to as 'farming' to a large, complex, and sophisticated industry which includes 'on-farm' and 'off-farm' activities. . . . agriculture has witnessed the introduction of automation and computers into its operations and structure and this has impacted greatly on the type of training needed by the industry's labor force. . . . A major problem for educational institutions . . . that have a responsibility for providing the agricultural industry with competent employees is keeping up-to-date with the types and levels of skills the employees need to possess. Too frequently, our educational institutions are equipping their students with obsolete skills, or skills that are not geared to the industry's needs—as they are and as they are becoming. Educational institutions, particularly those designed to provide vocational training, must do everything possible to make sure that their students are being equipped with the kinds of skills needed by the industry. (p. 17)

In the area of *industrial arts*, two authors briefly discuss instructional content and computer-based training. One author, Craft (1982), feels that the computer has the potential to be used as part of the instructional process for the industrial arts, but that software and courseware for this field are in short supply. He cites studies illustrating that the use of computers in industrial arts (mostly for computer-assisted learning) has already proved beneficial to students. However, he feels that in light of the software shortages, effective integration of the computer into such curriculum may be at least a decade away. A second author, Brook (1979), feels that there are several ways in which the microcomputer can be used in the industrial arts instructional process. These include being used—

- for communications and computational applications;
- as a device to control other instruments that students must use (e.g., lathe duplicator, plotter for producing student drawings, or a developer for photographic film);
- as a tool for design and drawing exercises;
- to calculate board-foot problems or determine quantities and costs of materials; or

- for analysis of test results using common statistical techniques.

For the *business and office area*, Lambrecht (1982) suggests many ways in which business educators can integrate the microcomputer into their instructional plans. In her opinion, the machines can be used for instructional support activities and as "tutors" to help students improve their business planning and decision-making skills. Additionally, she emphasizes the idea that the microcomputer must be used in conjunction with other educational materials. Toward this end, the business educator must evaluate software materials carefully for their educational merit.

Similarly, Drum (1981-1982) and Robinson and Johnson (1982) have written articles in which they offer special suggestions for integrating the use of the microcomputer into a business and office education curriculum. Drum's suggestions relate to a computer literacy course geared toward business and accounting students, while Robinson and Johnson focus on curriculum ideas related to the teaching of keyboarding skills for the business student. In addition to examining the need for special keyboarding instruction in the vocational business curriculum, these authors also describe how the microcomputer can be used to deliver course material.

Authors who discuss the use of the microcomputer in a vocational program area also frequently suggest that computer literacy and instruction relating to specific occupational content be combined. For example, Russell (1982) says that the microcomputer can be used in both ways for *marketing and distributive education* courses. As an illustration of this idea, he says that the microcomputer can be used to deliver competency-based instruction within the classroom. At the same time, students can satisfy requirements for computer literacy training through such activities as preparing an advertising campaign for microcomputers or reporting on new career tasks arising in the advertising field as a result of microcomputer technology.

CHAPTER III: COMPUTER-ASSISTED INSTRUCTION IN VOCATIONAL EDUCATION

As the reader may already know, today's authors use a variety of terms when referring to the use of computers in instruction. Such terms include *computer-based instruction* (CBI); *computer-assisted learning* (CAL); *computer-assisted adult learning* (CAAL); *computer-assisted instruction* (CAI); and *computer-managed instruction* (CMI). Generally, the choice of terms is determined by whether the author is writing about an instructional delivery system or about a particular group of related instructional applications.

In this publication, two broadly applied terms are used to refer to instructional computer applications. These are *computer-assisted instruction* (CAI) and *computer-managed instruction* (CMI). Terms such as *computer-based education* and *computer-based instruction* will not be used, as these labels usually refer to a computer-based delivery system that incorporates aspects of CAI, CMI, or a combination of the two.

In both theory and practice, it is often difficult to distinguish between CAI and CMI. This is because some of the existing courseware and software programs developed for instructional purposes are used both to deliver concepts and information to a student (CAI), and diagnose students' learning patterns and problems and prescribe remediation (CMI). However, the differences between these two types of computer applications are striking enough to warrant separate discussions. As a result, this chapter will focus upon (1) salient issues and challenges that CAI raises for vocational education and (2) the potential that CAI applications hold for vocational education. The next chapter will do the same for computer-managed instruction.

CAI: A Definition and History

The literature related to computer-assisted instruction contains a variety of definitions for the term. Some authors suggest that any instructional use of the computer is CAI, while others are much more specific in regard to the types of instructional applications that can be considered as CAI. Inherent to all definitions, however, are the concepts that the computer can be helpful in delivering instructional materials to students, and that the term *CAI* itself encompasses several different learning strategies.

Frenzel (1980) describes and defines CAI as

> the process by which written and visual information is presented in a logical sequence to a student by a computer. The computer serves as an audiovisual device. The students learn by reading the text material presented or by observing the graphic information displayed. The primary advantage of the computer over other audiovisual devices is the automatic interaction and feedback that the computer can provide. Multiple paths through the course material can be taken, depending upon the individual student's progress. (p. 86)

The concept of CAI is not new. According to Frenzel, its origins are traceable to a machine designed to grade multiple-choice exams that was invented in 1924 by Dr. Sidney Pressey. During the late 1950s and early 1960s, the work of B. F. Skinner and others in the area of teaching machines and programmed instruction improved and expanded upon Pressey's work. Although such teaching machines were used, they never became popular because of a lack of both content standards and teaching materials. In the late 1960s, however, came the discovery that programmed instruction could be implemented via computer, and for a while there was a flurry of developmental activity devoted to computer-aided instruction. However, the cost and the size of computers available during the 1960s meant that large-scale implementation of CAI projects was still not possible.

With the introduction of the minicomputer and the development of a project called PLATO during the late 1960s and early 1970s, a new round of interest in CAI was initiated. A computer-based educational network, the PLATO system demonstrated for the very first time that CAI could be beneficial to students. However, the costs of these minicomputer systems still placed CAI beyond the reach of most schools and districts.

It was not until the introduction of the microcomputer that widespread access to computers for the instructional process (and, consequently, CAI as a teaching strategy) became possible. Because of the relatively low cost of this machine, many schools and school districts can now afford to introduce CAI into the curriculum. The vocational administrator or educator undoubtedly wants and needs to know (1) whether CAI delivered by the microcomputer is indeed an efficient, beneficial, and cost-effective instructional method and (2) how CAI can best be used as a teaching or instructional strategy. Unfortunately, there is no one document or source of information that will provide concrete answers to such questions. There is, however, a large body of literature that can help the vocational educator arrive at sound decisions regarding the use of this technology for the delivery of instruction.

Implementing CAI

CAI can be implemented in the academic or vocational classroom in several different ways. Forman (1982), for example, cites three possible "modes" or strategies for implementing such instruction: drill and practice, tutorial programs, and simulations. In contrast, Molettiere, Konsynski, and Stott (1980) recognize six possible instructional modes: problem solving, drill and practice, inquiry, simulation or gaming, tutorial instruction, and authoring. Although a consensus has not yet been reached on exactly which of these modes are or are not appropriate for CAI, it is important to understand the definitions of some of the more common modes:

- **Drill and practice:** This use of the computer takes "advantage of the computer's tireless patience and ability to provide immediate feedback and reinforcement to prescribe, provide, and monitor potentially very complex drill and practice activities which can be tailored to a student's individual needs" (Forman 1982, p. 44).

- **Tutorial:** "Depending on the capabilities and the storage capacity of the computer system, [this use of the computer is a dialogue] between the learner and the designer of the educational program. The computer acts as a 'tutor' to teach the student concepts and skills. . . ." (ibid.)

- **Simulations:** In this regard, the computer is used ". . . to simulate or generate environments for the learner so [the student] can change variables and explore situations in a manner that might have been too expensive, too restricted by time limitations, too dangerous, or too impossible to allow the student to explore in the real world" (ibid.)

- **Problem solving:** "In this mode, the student uses the computer to solve problems that would take many hours or excessive computation to solve by hand. . . ." (Molettiere, Konsynski, and Stott 1980, p. 149).

- **Authoring:** "In this mode the machine uses algorithms and formulas to generate questions to present to the student. The course author supplies subject primitives, algorithms, and decision criteria and the computer can then generate random exercises for the student to use. . . ." (ibid., p. 150).

- **Inquiry:** "In this mode, a database of information is developed which the student can query for facts about a topic. An example of the inquiry mode is PIP, or "Product Information Package"—a database of product information that marketing personnel can use to keep up-to-date on tariff status and product options" (ibid., p. 149).

Why CAI?

Most experts already agree that as vocational education makes more extensive use of computers, students will begin to learn faster and better. As a result, it is possible that a greater percentage of students will know earlier whether they really desire to (and profitably can) pursue the career they are working toward. One result will be a general raising of standards in vocational education.

One field-based expert who participated in this study observed:

> The outlook for existing careers is bright when skills are taught with the help of microcomputers. Vocational education has the advantage of dealing with known methodologies. There is a right way to carve wood and a right way to rebuild car engines. This environment is well suited for the use of a microcomputer. Such skills can be demonstrated with the help of a microcomputer, and computers can repeat a demonstration for days without feeling bored or frustrated.

In exploring the benefits of CAI, it is essential that the reader first understand how microcomputers differ from the original mainframe computers. The work of Lee (1982) and Herriott (1982) offers insights into this issue.

According to Lee, the small, independently operated microcomputer units possess one critical capability not found in older equipment: the ability to interact directly with the user. Theoretically, therefore, this capability allows instruction delivered on this machine to be individualized. In her words—

> Interactivity is the current technological buzzword—and with good reason. Theorists have long agreed that the most effective learning occurs when the learner has a sense of control, is actively involved, gets immediate feedback, and has a high level of expectation about his or her ability to master the material . . . computer-assisted instruction (CAI) does just that. (p. 18)

Lee goes on to relate a conversation with John Hirschbulh, manager of computer-enhanced training at the Chicago-based Deltak firm, in order to support her assertions. In this conversation, Hirschbulh noted that through the microcomputer's interactive capabilities, CAI instruction adapts to the student's needs by taking his or her response to a question, processing the response, and coming back with the next required piece of instruction. When evidence is given that a student has mastered the concept or instructional objective, the lesson proceeds.

Writing in a similar but somewhat more specific vein, Herriott provides a more detailed listing of CAI's attributes when offered via microcomputer. He suggests that the computer can—

- Impart information on a one-to-one basis with a high success rate when well-written and thoroughly validated programs are used;
- Provide imbedded remedial instruction of which the student may not necessarily be aware;
- Provide enrichment material within the program;
- Keep accurate track of progress throughout the program, and, indeed, throughout a series of programs on varied material;
- Allow the student to progress at his or her own rate;
- Provide video and audio support via peripheral devices linked directly to the computer; and
- Provide a massive information retrieval base—either by direct display of the material itself or by directing the student to the appropriate medium.

Field-based experts who participated in this study note at least two additional reasons for intensifying the use of microcomputer-based CAI in vocational education: (1) research on CAI shows that students learn very well with CAI if they like the subject matter and have a stake in learning it (two qualities that vocational students possess) and (2) an increasingly high percentage of jobs now involve computers. This latter situation is encouraging schools to give their students an edge by making as much use of computers as possible. It is especially true in business education, for which hardware and software are now inexpensive enough for students to use the same equipment and programs that are used by workers or business people. Specifically, word processing, payroll, accounting, inventory, and financial planning programs were cited in this regard.

To summarize, vocational education topics do no present significantly greater or lesser problems to CAI delivery than do other educational programs. The advantages of CAI, such as motivational improvement, self-paced learning, and individualized instruction, do, however, make CAI especially attractive for use in vocational education. In addition, the potential for utilizing the microcomputer in simulation provides unique opportunities for vocational education. The instant recall and flexibility provided to an instructor offer almost unlimited opportunity for applications of the microcomputer. In addition, future software developments will provide a tremendous tool for the presentation of classroom materials. Color and graphics capabilities will most likely replace overhead projectors and other such audiovisual aids utilized by instructors today.

Some Basic Caveats

In light of the enthusiasm and novelty now surrounding microcomputer-based CAI, it is important to understand some of the possible drawbacks to such systems. For example, Corgan and Spitler (1979) warn that the recent rush to use computer-assisted instruction has produced an incredibly large number of mediocre programs that pose erroneously as CAI. All too often, they say, the microcomputer is touted as a cure-all or panacea for education's problems. Because of this fact, individuals using the microcomputer for CAI programs often do not question seriously whether the computer is the correct tool or instructional medium for a particular task. Along this same theme, Shane (1982) cautions that educators generally need to define more clearly among themselves which instructional methods are the best and what the goals of education should be. From his perspective, educators have much to learn about the learning process and about individual differences in learning styles.

In examining the concept of learning from the cognitive, intellectual, and psychomotor dimensions, Steffin (1982b) suggests that the microcomputer can be used for instructional purposes in any of the three domains. He notes, however, that such CAI systems will work most successfully in situations where learners' objectives are clearly defined and agreed upon and in teaching those skills for which there are clear measures of achievement. When such conditions are not met, other instructional media should definitely be considered.

Determining the Effectiveness of Microcomputer-Based CAI

Unlike most other teaching methods or technologies, microcomputers offer students the opportunity to follow a number of different learning directions or "paths." For example, if a student has already mastered part of a computerized lesson, he or she may choose to skip that section of instruction and "branch out" or proceed into new material. In other cases, the student may need to spend extra time reviewing difficult sections of the lesson—a process that is well facilitated by the microcomputer's backtracking or "looping" capabilities.

Clearly, therefore, the microcomputer offers to the vocational instructor a technology that is not only different from the earlier mainframe computers, but also from other audiovisual media such as films, filmstrips, and audio and video tapes. These latter items in particular allow only one path through the instructional material from start to finish. As such, they do not permit the same options for creating totally individualized and interactive instruction that the microcomputer does.

Because CAI delivered via the microcomputer is still a relatively new practice, however, there are many questions that need to be asked and answered before the machine's effectiveness for classroom instruction can be adequately determined. Admittedly, a body of literature that examines the effectiveness of CAI delivered by the mainframe computer already exists. However, the differences between the mainframe and the microcomputer are distinct enough to warrant a specialized examination for the latter.

In establishing a perspective on the type of microcomputer-based CAI research that is needed, Spencer and Baskin (1981) feel that a number of specific questions need to be examined:

- Do all subjects lend themselves equally well to computerized instruction?
- What length of time should be spent on a particular lesson before proceeding to the next?

- Does the length of time vary according to age and grade level?

- What is the best combination between computerized instruction and other learning activities?

- Does extensive use of the microcomputer foster cooperation or isolation in the student's learning process?

- What types of reinforcement techniques are most appropriate when the microcomputer is used?

- What is the best way to utilize the computer for instructional purposes?

- What is the optimum time for students to be scheduled on a computer at any one time?

Gleason (1981) explores the issue of microcomputer-based CAI by first summarizing the results of research on computer-based CAI. In his opinion, this past research has demonstrated the following:

1. CAI can be used successfully to assist learners in attaining specified instructional objectives.

2. There appears to be a substantial savings in time (20 percent to 40 percent) required for learning via CAI as compared to "conventional" instruction.

3. Retention following CAI is at least as good as, if not superior to, retention following conventional instruction.

4. Students react very positively to good CAI programs; they reject poor ones. (p. 16)

Gleason further suggests that few serious researchers are interested in comparative studies between CAI and other, more conventional instructional strategies (perhaps because of the extreme difficulty of controlling the large number of significant variables in most instructional settings). Rather, he indicates that educators and researchers are focusing on a different set of problems, especially in relation to the microcomputer. For instance, he says that researchers are asking about the effectiveness of various CAI strategies (e.g., drill and practice, tutorial, simulation) over others. Associated with this concern are questions about—

- the frequency and type of feedback that is most effective for the student;

- the point in an instructional program when feedback should be offered; and

- the types of learner interactions that are most productive.

A second set of concerns focuses upon the individual student's learning style and the effectiveness of CAI. Gleason suggests that research is needed to answer questions about the amount of cognitive complexity a learner can manage and which CAI strategies are most appropriate for what types of learners. From his perspective, microcomputer technology has researchers and educators alike asking about the effects the microcomputer has on individual learner characteristics, such as memory span, perceptual skills, sensory preferences, and intelligence. Additionally, the researchers are giving attention to determining which *affective* characteristics of the individual learner are most important to the design and development of CAI microcomputer applications (e.g., motivation, persistence, delayed gratification, locus of control).

Gleason also states that a third set of issues receiving attention from researchers center around the creation of appropriate software and identification of effective CAI instructional strategies. These issues are expressed in such questions as—

- What are the most effective stragegies for CAI program development?
- Which hardware configurations are most effective and efficient for various types of CAI programs (e.g., audio, touch-sensitive screens, videodisc)? and
- What are the most effective strategies for integrating CAI with other instructional media?

Authors Bagely, Hansen, and Klassen (1979) suggest that an evaluation of success and effectiveness of the use of microcomputers in the instructional process will require an assessment of all the benefits that are theoretically available to the student when CAI is delivered by such equipment. Theoretically, these benefits might include the potential for individualized, self-paced instruction; immediate learner feedback; and an increased amount of teacher assistance.

Finally, to give the reader a perspective on the results of preliminary research in this area, we will examine the study conducted by Jelden (1980) at the University of Northern Colorado at Greeley. With the objective of testing whether or not it is educationally possible to justify the microcomputer as a valid instructional tool, Jelden first generated a set of individualized CAI materials for use in industrial arts and electronics classes. Using these materials with a total of 201 university students (ranging in rank from freshman to senior) over a period of seven quarters, Jelden found that—

- 94 percent of the students said that the microcomputer was preferable to other media for teaching concepts and principles;
- 90.5 percent responded that the microcomputer was as good as or better than other media for providing information and promoting retention; and
- 91.5 percent liked the immediate feedback capabilities of the microcomputer.

Statistical tests during the study also showed a correlation between the number of CAI lessons completed and grade levels.

Needless to say, not every vocational instructor who elects to use a microcomputer needs to be concerned with or responsive to the complete gamut of "research" questions and issues discussed here. However, if the decision is made to offer microcomputer-based CAI in the classroom, most of the concerns expressed by these authors will have to be addressed either directly or indirectly at some point during the development or implementation stages.

Examples of CAI Use in Vocational Education

A body of literature is developing which suggests that microcomputer-delivered CAI either is being used or can be used beneficially in vocationally oriented education. Two primary perspectives are represented in this literature: the use of CAI in the traditional vocational classroom and the application of CAI for training and education in private industry. Examples from each area will be presented in the following sections.

CAI Use in Vocational and Technical Schools

Unfortunately, although a number of authors have reviewed the benefits of using microcomputers in the vocational classroom, much of this literature remains undocumented in quantitative terms. However, there are some authors whose work is based on actual classroom observations. For example, Orr (1982)reports that microcomputers and a combination of both CAI and computer-managed instruction (see chapter 3) actually provide the Leto Comprehensive High School in Florida with the equivalent of free teachers. He says that a CAI program for the school's network of sixteen terminals provides the equal of an additional teacher unit each hour that the system is in operation. The school is currently working on a program that will allow each business student to gain hands-on experience in operating computers. Eventually, a large percentage of vocational students are expected to be instructed with this program. Additional computer applications are being planned for English instruction, typing, business, communications, math, masonry, electrical wiring, food preparation, auto mechanics, and law enforcement.

Other authors take the perspective of the microcomputer's application to instruction in specific service areas. For example, the following illustrations are highlighted from the *business and office education* area:

- The New York State Education Department (1980) published a compilation of fifteen significant educational projects in the fall of 1980. Of the fifteen projects, one related to microcomputers. At Suffolk Community College in Selden, New York, the microcomputer is used as an interactive teaching tool in a statistics program for career-oriented students. The program emphasis addresses the teaching of statistics in a manner that increases students' interests and exposes them to the use of modern informational analysis techniques by using an interactive teaching strategy.

- Kenneke and Suzuki (1981) compiled a directory of outstanding projects in career and vocational education in Oregon. One program was identified involving microcomputers. Utilizing CAI, the project is an office simulation designed for eleventh and twelfth grade students in the accounting and business machine cluster. The objective of the program is to train students for entry-level clerical and office occupations. Procedural manuals, sample worksheets, and software programs for the TRS-80 have been developed as part of the project.

- Lambrecht (1982) explains CAI applications in the business classroom that include: drill and practice programs in typewriting, spelling, English style and grammar review, and vocabulary review; tutorial software for accounting, business law, business communications and economics; and simulations used as a follow-up to tutorial software or regular classroom instruction for economic decision making, business management, or accounting.

From the program area of *industrial arts education*, the following brief illustration is offered:

- Wolfe (1978) writes that computers can be used for certain instructional tasks for technician education. This is especially true for teaching accurate reading techniques for a number of measurements, such as voltage, current, decibels, resistance, and oscilloscope readings (including phase, magnitude, and frequency). He illustrates (1) how the computer can be used for CAI by delivering physical modeling problems to students and (2) how the computer can provide specialized simulations (e.g., those involving chemical processes) for technical instruction. According to the author, the applications can be appropriate for a micro, a mini, or a mainframe computer. He advocates their use as part of an integrated instructional process that attempts to provide a hands-on training experience and that focuses on specific learning objectives.

CAI Use in Private Industry

Kearsley, Hillelsohn, and Seidel (1981-1982) recently overviewed some of the many ways in which the microcomputer is being used for vocationally oriented CAI applications in private industry. They surveyed a total of 160 major corporations to determine (1) whether they used computers for their in-house training programs and (2) whether they did use computers. Of those surveyed, 56 companies responded, and of that number, about half said they used computers for in-house training. Of this number, 20 (about 71 percent) said that they used microcomputers. Generally, the major applications for which the microcomputer was used were technical skills training, management/sales training, clerical/administrative training, programming/computer literacy, and training management. Of these five applications, technical skills training was the most common. The instructional strategies most commonly used were simulation, exercises, drills, tutorials, job aids, and data management. Simulation was the most common. Here are some examples of specific applications found within companies:

- At the Xerox Corporation one project uses microcomputers to offer tutorial instruction for service representatives. Courses include: Service Call Management; Machine Installation Procedures; Technical Updates; and Reported Field Problems.

- At Guaranty Mutual, an insurance company, microcomputers are used to provide simulated sales situations.

- At the Eastman Kodak Company, microcomputers provide equipment troubleshooting practice for service representatives. Schematics of equipment are displayed on the screen and a light pen is used to measure voltages. When a malfunction is located, the light pen becomes a soldering iron that can be used to repair faulty equipment.

- American Express Company is using specially designed microcomputer-based simulators to teach data entry and inquiry skills for the IBM Series/1 computer. The microcomputer allows complete simulation of the actual job with embedded pretests and posttests.

Authors Quy and Covington (1982) report that the development of microcomputers has opened many new opportunities for company trainers. With these computers, the authors say, trainers can more easily meet the training and retraining needs of employees at different corporate levels. They go on to cite randomly selected examples of microcomputer-delivered CAI applications in private industry. Several firms, including General Motors and Heliflight systems of Texas, use the microcomputer to deliver basic skills instruction. Drill and practice instructional strategies used in company settings include salesperson training at Eli-Lilly's Elanco Division and at Jeppenson Sanderson in Colorado; telephone installer training offered for Mountain Bell at Tucson, Arizona's Pima Community College; troubleshooting and missile repair at the U.S. Army's Redstone, Alabama site; and simulated cardiopulmonary resuscitation training at the American Heart Association in Dallas, Texas.

The CAI Software Problem

General Software Concerns

No matter what instructional task, educational skill, or training program area the microcomputer is used for, most authors agree that the technology clearly suffers from a lack of quality courseware or software. As one field-based expert who participated in this study noted:

> The ultimate success of any microcomputer-based instructional delivery technology will be highly correlated with the versatility of the technology. Anticipation by the computer system itself of the needs of a particular student and other such "intuitive" processes will become the dividing line between an adequate technology and a remarkable one. Too often the tendency is to accept something [that is] effective as being sufficient to answer a need. This tendency is particularly dangerous in the realm of software. We must stretch the limits of current instructional technology. Many areas of research in human/computer interfaces, artificial intelligence, database structure, simulations, and games are all appropriate to be drawn upon in the evolution and design of instructional technology.

In explaining why this situation exists, Meyers (1980) notes that the software industry is currently quite fragmented because each producer must generally design its product for use on one particular hardware system. This is because hardware systems from different companies are simply not compatible—thus software designed for one system cannot be easily run on other systems. In order for the producers to make a profit on their efforts, therefore, they must focus their development efforts on the most versatile "general use" programs they can. Meyers also feels that the current software dilemma exists for the following reasons:

1. Software companies often do not produce their own programs from start to finish because of the scarcity and cost of skilled programmers. Thus it is common for a software company to contract with an outside company for programming services. Once the programmer's work is finished, the software company then reviews and refines the program with a concern for program performance and visual content.

2. In the process of mass-producing software, technical problems can arise with the tape or disk on which the program is duplicated.

3. As far as education is concerned, the software industry is generally still in the experimentation stages because it has not been made aware of the field's overall needs and concerns.

4. A user's hardware system may cause technical problems with the software program.

5. The documentation for a software program may be too complicated for the user to understand.

6. When needed in volume for classroom use, microcomputer software can become quite expensive. As a result, educators frequently purchase one copy of a software program (or borrow it from a colleague) and then produce multiple copies—thus eliminating the need for large purchases from the vendor. Because of such practices, software producers do not view education as a profit-making area for their efforts, and subsequently turn their attention to other disciplines.

7. Because of the large number of hardware systems that exist, there are marketing problems for software.

Koetke (1982) echoes some of these same perceptions, saying that educators should not view the majority of today's instructional software as representative of the computer's educational potential. He points out that there are fewer examples of new software today than there were a year ago because many smaller producers have left the market—and have taken with them a great deal of creativity and imagination. Furthermore, the more well known educational publishers entering the software market often act more as brokers than producers by marketing software produced from external sources rather than producing their own. For these reasons, Koetke suggests that consumers do not assume that material from traditional publishers is better than that produced by newer, smaller firms. He closes by saying that even though the software industry has been around for twenty years, it is yet a young industry because it must now deal with the general public as opposed, in the past, to computer professionals.

Zakariya (1982) assesses the current software situation by saying that much of the material now available is little better than an electronic workbook. Similarly, Dwyer (1980) calls for more diversity in the creation of CAI materials from both commercial publishers and educators who author their own materials. He says that all too often, educators and publishers assume that what we presently define as instruction is the best way to promote human learning—thus believing that the role of technology is merely to automate this process. From his perspective, CAI programs need to be more than the drill and practice, multiple-choice packages that presently pervade the marketplace.

Special Software Concerns for the Vocational Educator

Vocational educators face a number of software concerns in addition to those outlined previously. For example, the mere fact that vocational education is somewhat specialized means that the issues related to research and courseware development become more pressing for vocational education than they are for general education. Work needs to be done, for instance, to determine which of the various CAI strategies best delivers instruction for a given task or competency within an occupational program. Similarly, a large portion of vocational education instruction is of the hands-on, psychomotor variety. Specialized, fairly technical software may be needed in order to use the computer effectively for this type of training.

A third issue that will confront the vocational educator is the growing trend for vocational education to be used for training and retraining adults. Literature indicates that the software and CAI strategies needed for this population differ from those needed for the secondary student. Research is consequently needed to document and substantiate this claim.

A fourth issue centers on the fact that the market for vocational education software is smaller than that for general education software. This means that commercial software publishers will not be able to realize as large a profit from vocational software as they will from software prepared for the general education market. Because of this, there may be a smaller supply of "canned" or commercial software programs available for many vocational education courses.

Yet another issue focuses on the fact that the vocational curriculum must to some extent reflect the requirements of employers of a given locale. Because of this, mass-produced, commercially prepared software will not, nor can it be expected to, satisfy the local curriculum needs of many vocational programs. Given this situation, the ability of the vocational community to somehow generate its own software becomes extremely important.

Commercial or Locally Produced Software?

In light of the current CAI software dilemma, several authors have commented on the possibility of having users develop their own software. While such program authoring may be unrealistic for many if not most instructors, a general knowledge of the advantages, disadvantages, and procedures involved in this process may be helpful. Several authors suggest that, first of all, more dialog and partnership is needed between the instructors (software consumers) and those who actually write the programs. In addition, educators in general need to learn how to identify high-quality courseware. If instructors knew enough about software design to be able to evaluate and select software geared for their instructional objectives, they could provide valuable insights to those who create the materials—thus ensuring the creation of appropriate, high-quality materials.

Tesch (1980) comments on the issue by noting that when commercial software is used, there is no need for the user to have a knowledge of computer capabilities, programming languages, or logic processes. In addition, no lead time is needed for planning and development. In contrast, if instructors or other school personnel decide to develop their own software, they will need to know at least one computer language (such as BASIC), the capabilities of the particular microcomputer they wish to use, and a method for solving the specific instructional task. Despite such drawbacks, however, he still feels that there are three major advantages to user-designed software, namely—

- that the user has a better overall understanding of the program,
- that needed debugging can occur immediately; and
- that program adjustments and changes in course materials can be made easily and immediately.

In a similar vein, Michael (1981) concentrates on the disadvantages of commercial software. Noting that at the present time there are simply not enough "canned" programs available for their overall quality to be judged, he also feels that for some courses, the commercially prepared programs may never be suitable. When instructors prepare their own programs, however, the content of instruction can be controlled, remedial programs can be tailored for individual students, and programs can be modified at any time. In terms of specific benefits resulting from user-designed and developed courseware, he suggests that—

- students respond best to courseware that is personalized and interactive;
- instructors can prepare short, simple programs or more in-depth versions of the same material;
- any question desired can be asked of the student and any relevant information can be presented either before or after the question;
- both right and wrong answers can elicit computer responses; and
- the number of correct responses can be charted and displayed by the computer.

Whether a decision is made to have instructors and school personnel write instructional programs or to use commercial CAI material, the need for quality courseware must still be addressed. Often, it is unrealistic to expect instructors to develop their own courseware, especially if a given individual is not an experienced computer programmer. There are software authoring packages on the market that will help the novice programmer develop instructional materials. However, the literature suggests that even with the assistance of these packages, the creation of quality instructional software is time-consuming and expensive. Estimates vary for the ratio between the amount of development time that is needed and the total amount of software produced. However, current estimates are that at least 200 hours are needed for a developer to produce one student contact hour of software. This is because the development of courseware for the microcomputer embraces such a multitude of considerations.

The Process of Software Development

For those education personnel who wish to develop their own software, Kosel (1980) provides a detailed description of the development process. In her view the process covers a total of six stages including analysis, preliminary planning, design, screen layout, programming, and testing. Within each of the six stages, she then lists a variety of factors (or, at times, tasks) that the developer should consider.

As an illustration she suggests that during the analysis stage, an instructor should—

- define goals;
- examine teaching techniques for reaching goals; and
- decide which of the computer's features will add to the materials' presentation.

Similarly, for the preliminary planning stage, she recommends that the instructor—

- determine the hardware system(s) on which the program is to run;
- decide who will use the program;
- determine the broad subject areas to be taught;
- choose from the broader subject areas the material that is to be developed for the computer;
- organize the material into lessons with each one demonstrating one concept;
- establish how much of the material is to be presented with the computer, and how much with other media;
- determine how to present instructions to the students;
- determine how graphics are to be used;
- consider how sound should be incorporated (e.g., should use of headphones be considered); and
- if color graphics are to be used for enhancement, consider the design of illustrations to be used on the screen.

Clearly, it is not possible here to investigate completely the principles and guidelines of software program design. However, the previous discussion suggests that proper design of course material for the microcomputer is a task that requires some time and effort, especially if the software programs are to be used in an integrated fashion with other instructional tools and strategies. While it is unrealistic (because of time and cost constraints) for every instructor to author his or her own instructional software, it is not unreasonable to expect an instructor to have a knowledge of software design criteria. Instructors, whether vocational or nonvocational, need such knowledge for at least two reasons: (1) instructors who understand such criteria can work effectively with a programmer or designer who may be designated as a courseware author within a school or district, and (2) instructors can employ such information when they evaluate and select either commercially prepared software packages or programs prepared by educators outside of their own locale.

Current Methods of Solving the Software Problem

The problem of inadequate software can be addressed in a variety of ways. As yet, however, most of these efforts are somewhat isolated and, at best, only partial solutions to the existing problems. This is primarily due to the fact that national leadership for the development and dissemination of instructional software materials is virtually nonexistent. There are several state and regional efforts that are providing leadership assistance. However, for the most part, local schools and districts must come up with their own solutions to the software problem.

At the local level, there are several options open to schools. Instructors can produce their own software, although, as has already been discussed, this is probably unrealistic. Barring this solution, schools or districts can assign specific instructors or outside programmers to work with instructors to create software programs. This type of approach is being utilized at Lyons High School in LaGrange, Illinois. In this location, teachers identify computer applications in conjunction with subject-area coordinators who possess both subject-specific expertise and knowledge of computer applications. These coordinators work with both classroom instructors and computer programming specialists to develop instructional courseware for the school.

In other situations, often a university or a technical or community college will help locate or develop software for schools or school districts. For example, Leising and Wilkens (1981) have described a project in the field of agriculture that was undertaken for California's community colleges. As part of an inservice training effort, resource manuals were prepared for the agricultural faculty at the state's two-year institutions. In the manual, profiles were presented of over 100 software programs in agriculture that were available for the microcomputer. The programs were grouped by specific headings (e.g., crops, horticulture, animal science). Each profile contained descriptive information about the program, including costs, authors, hardware specifications, content, and information pertinent for obtaining the program.

A similar type of effort for the agricultural field has been undertaken in Minnesota. Dean (1982) describes the state's efforts to locate microcomputer courseware for secondary school instructors. He says that the effort involved (1) development of original or modification of existing software by an agricultural extension economist at the University of Minnesota; (2) location of a wide variety of public domain software from other land grant colleges; and (3) the obtainment of copies of software programs that have been developed by agricultural instructors and extension personnel.

According to Dean, there was actually a vast number of software programs available for secondary vocational agriculture. As a result, significant effort was expended to help vocational instructors identify the software that most closely met their needs; rewrite user documentation for many existing programs so that students could use them more easily (this effort included such activities as providing additional technical information, developing worksheets to accompany courseware, etc.); and modify much of the software itself to make it easier for students to use.

Other efforts similar to these are occurring around the country. Many of them, however, are not so focused in terms of location or subject area. There are three efforts in particular that are aiding instructors from around the country in various ways. These are the Minnesota Educational Computing Consortium, the MicroSIFT software clearinghouse at the Northwest Regional Educational Laboratory, and the San Mateo (California) Education Resources Center. These groups engage in a variety of software-related activities that assist educators both in their respective states and in other areas of the country. Some of their efforts include publication of newsletters, assistance with software selection and evaluation, software exchange programs, development of original software materials, and technical assistance for such areas as teacher inservice programs or computer literacy training. Not all of these services are provided at each of the sites. However, the activities of any one of these groups are diverse enough to provide a broad source of information and assistance to educators in general.

In summary, many issues regarding software development and use need to be confronted and solved. As examples, the following are offered:

- Creative thought is needed regarding the appropriate role of public and private sector entities in the software development process.
- Attention will need to be given to the establishment of programming standards and to decisions governing course content.
- Resources will have to be found to support software development efforts.
- A mechanism will have to be established to coordinate the various isolated efforts that are occurring within the educational community itself to increase the supply of quality software.
- Research efforts are still needed regarding both the effectiveness of CAI and the software that will best support CAI as an instructional tool. Decisions need to be made regarding where the research is to be done and how it will be financed.
- Individuals will have to be trained to design the needed software.
- Consideration must be given to methods for integrating software materials produced for the national market or in other localities into the curriculum objectives of the local area.

CHAPTER IV: COMPUTER-MANAGED INSTRUCTION IN VOCATIONAL EDUCATION

Definition and Uses of CMI

Just as the term *CAI* is subject to a variety of different interpretations, the term *CMI* is viewed in different ways by different authors. From the literature, it appears that three major "definitions" of CMI have emerged—each one highly dependent on the type of application in a particular context.

Authors Mosow and Price (1981), for example, feel that the use of the microcomputer for *classroom administration* is one of its most promising applications. Noting that software programs specifically designed to handle record keeping tasks are now readily available, they report that teachers can increase their individual productivity by using the microcomputer for such functions as generating student tests, preparing instructional evaluations and progress reports, compiling lists of students who have successfully met course objectives, and issuing daily reports on attendance. Similarly, Douglas and Neights (n.d.), Hannum (1981), and Nasman (1982) report that the microcomputer can help to increase a teacher's productivity through its ability not only to monitor a trainee's progress through a curriculum, but also to prescribe appropriate remedial activities for any deficiences encountered.

In contrast, Botterell (1982) emphasizes the microcomputer's ability to provide a diagnostic, prescriptive aspect to the actual *instructional* process by explaining how the computer can take on managerial chores formerly carried out by the teacher. He indicates that in CMI, "the computer takes on the managerial chores of individualized instruction by prescribing and monitoring each student's custom-tailored course of instruction. Such systems call on the whole collection of instructional resources in a school, including teachers, books, audiovisual materials, and even CAI programs, based on each individual's diagnostic test results" (p. 51).

In a similar vein, Watts (1981) suggests that instructional management applications are those that integrate class test data and computer-stored instructional activities so that group and individual learning plans can be developed to meet the learning needs of all members of a class. For example, the computer may be used either to print different assignments for each group in a classroom based on class test results or to identify the skills mastered by each student. In both cases, the teacher is better able to tailor instruction to the progress of each individual.

Finally, authors Molettiere, Konsynski, and Stott (1980) view CMI as *both* a supportive aid for the instructor and an interactive learning tool for the student. In their work, they divide CMI into two major parts: internal and external. Internal CMI deals primarily with the testing cycle: test construction, delivery, response collection, response judging, and feedback of results. Also included are programs that analyze the results and prescribe a course of action to remedy any deficiencies. External CMI is composed of systems to schedule resources, such as classrooms, instructors, materials, or terminals; systems to generate reports for instructors or administrators on tests, students, or resource usage; and systems for general accounting of resources.

Why CMI?

The importance and influence of CMI is often overshadowed by the attention focused on CAI applications. However, the literature suggests that CMI is potentially just as meaningful or even more meaningful for the instructional process than is CAI. In fact, according to Allen (1980)," . . . many researchers and developers feel that this form of computer application is not only the current backbone of many educational successes, but also the basis of some of the most important educational innovations to come."

Other authors who are not so emphatic about the merits of CMI over CAI do nevertheless underscore the importance of CMI for instructional and classroom management purposes. One such author is Denis (1979), who feels that the importance of CMI in education is growing for several reasons, including—

- increasing demands for accountability;
- a general decline in school resources; and
- a growing awareness of the effort required to deliver computerized instruction adequately.

No matter what reason is used to justify the use of CMI in the classroom, however, it is clear that instructors who use this system will have a set of extremely valuable educational computer applications at their disposal. Denis (1979) lists the following nine possible uses for a CMI system in the classroom:

1. Diagnosing
2. Assigning or prescribing
3. Facilitating study
4. Evaluating
5. Data collection or manipulation
6. Reporting
7. Resource and space management
8. Providing an information network
9. Materials implementation

How Effective Is Microcomputer-based CMI?

As is true of the literature available for CAI, there are a number of studies that document the effectiveness of CMI delivered on a mainframe computer, but very few that document the technique's effectiveness when delivered by microcomputer. This may be partially explained by the fact that the use of the microcomputer to deliver CMI is still a somewhat new occurrence.

There are, however, a variety of papers and articles indicating that CMI is being used in vocational and nonvocational classroom settings and that the individuals using the applications are finding them to be both effective and valuable. While these writings cannot be the sole criterion upon which a vocational administrator or instructor should base the decision to develop and implement a CMI application, they can illustrate the many ways that CMI can be useful. Therefore, a number of current studies from both the vocational classroom and the military will now be reviewed.

CMI In the Vocational Classroom

One of the studies conducted by Boas (1979) compared the effectiveness of instruction in reading micrometer measurements when delivered by three different instructional modes: CMI, lecture, and individualized modules. The study was conducted with both university-level graduate students and high school students in drafting classes at Delcastle Technical High School in Delaware.

As achievement scores in the study were highest for those receiving the CMI mode of instruction, it was concluded that, first of all, CMI can be an effective mode of instructional delivery for most vocational subjects in a classroom setting. Second, the CMI instruction that was developed and implemented during the study can serve as a prototype for curriculum in other occupational areas. Boas maintains that such findings indicate the viability of CMI as both an instructional method for students and a record keeping tool for teachers.

A study conducted by Pyle and Cook (1978) examined the feasibility of using CMI to provide inservice training for vocational personnel—a problem that needs attention especially in regard to instructors who come directly to vocational education from business or industry. In their study, Pyle and Cook asked whether such teachers should have to follow the practice of enrolling in university courses over a six-year period to meet certification requirements, or whether they should be allowed to study on an individual, as-needed basis.

To answer this question, the authors developed twenty instructional modules and a procedure for evaluating the effectiveness and efficiency of the modules. Fifteen vocational instructors were then asked to participate in a program designed to reduce the time that they would have to spend in a formal classroom setting.

As a result of the project, twenty modules were prepared for CMI instructional delivery. Eight of the modules focused on teaching methods, seven dealt with school shop safety, and five focused on the history and philosophy of vocational education. The fifteen "instructor students" successfully completed the fifteen modules that dealt with teaching methods and safety, but the modules dealing with vocational education's history and philosophy were not used because of insufficient enrollment. Several positive outcomes were noted from the project:

- The "instructor students" liked the fact that they could work at their own pace.
- They understood the instructional materials and said that adequate material had been included.
- They indicated that the experience gave them a better idea of how to use individualized instruction in their own classrooms with their own students.

The participants had divided opinions about whether they preferred total computer delivery as opposed to the more traditional methods as they indicated that more work was required of them when the computer was used. However, they did like the flexibility and freedom of the self-paced instruction.

CMI in the Military

The military has been actively involved with CMI applications. Although the training environments and student populations associated with the military differ from those found in vocational schools, the literature related to this area does hold some interest for vocational education personnel interested in the development and implementation of CMI applications.

Ellis (1978) reports on a study comparing CMI to instructor-managed training (IMT) at the Navy's Propulsion Engineering School at Great Lakes, Illinois. In this study, training procedures for three specific job classifications—Machinist's Mate, Boiler Technician, and Engineman—were studied. The study began when thirteen course modules were developed for delivery on a CMI system. For those students who participated in the CMI group, instructional content, testing, and remediation were all delivered by the microcomputer. For the control group, these tasks were handled by the instructor. Results showed that there were no major differences between the two methods as evidenced by module and lesson test scores. For the comprehensive test, the CMI group scored lower. In terms of course completion time, however, the CMI group averaged one day less and instructors using the CMI method had more free time to assist students individually. The author suggests that the time saved with CMI could be used to train instructors in counseling techniques for academically slow learners and in student motivational techniques.

Hamovitch and Van Metre (1981) conducted a project as part of the U.S. Navy's development of its CMI program. The project was the result of an effort to automate the testing of the typewriter portion of the training required at the Radioman "A" School in San Diego. According to the authors, such manually administered and scored typing tests were lengthy and often inaccurate. In addition, no record was kept of the errors made by participants. As a result, the decision was made to automate the course using CMI applications.

Hamovitch and Van Metre's project itself was an assessment of the automated system. The objectives of the assessment were twofold: to determine whether tests of performance skills took less time under the automated system than with the traditional, manual methods, and to determine whether supplying students with daily computer-generated error reports would reduce the required training time.

Project results indicated that—

- the automated testing was more rapid than the manual methods;
- students receiving daily error distribution reports finished the typing portion of the course three days sooner than students who received none;
- the attrition rate for students receiving daily error reports was 15 percent, while the rate for those who received no reports was 35 percent, and
- a majority of the students favored the automated performance testing and daily feedback supplied by the error reports.

Final results indicated that the method enhanced the cost-effectiveness of the training and thus recommendations were made to extend the practice to other schools.

To ensure that a CMI system is the most effective means for dealing with such tasks, however, it is important for the reader to understand the implementation, general effectiveness, and current applications of such systems. Each of these aspects will be covered in the following sections.

Implementing CMI

Unlike computer-assisted instruction, computer-managed instruction can be initiated on either a schoolwide or individual classroom basis. Yet no matter what form of implementation is chosen, special attention must be given to two primary factors: the role of the classroom instructor and the design of the instructional curriculum. Denis (1979), for example, points out that during the preparation of materials to be used with a CMI system, the instructor might be responsible for planning, organizing, commanding, and controlling the entire implementation process. He also suggests that the following questions be considered in order to illustrate the breadth and complexity of issues that the instructor must address when preparing instructional materials for CMI applications:

1. What instructional objectives should the instructor choose to present?
2. What are the instructional prerequisites associated with each objective?
3. How will the instructor know that a student has mastered the objective?
4. What type of organizational pattern will the instructor use to present the material?
5. Are remedial resources likely to be needed?
6. What actions or instructional resources should an instructor use when no more remedial assistance is available within the computer-based material?
7. What student performance data should the instructor collect?
8. What pacing procedures are to be used when presenting the material?
9. What type of testing, if any, is to be used?
10. How frequently are tests to be administered?
11. What are the criteria for tests?
12. What resources will be used for study?
13. How will resources and the use of the resources be scheduled?
14. If grades are to be administered, how and when are they to be assigned?

Gundlach (1981) also offers some insights into the types of efforts and decisions that are needed before CMI can be implemented in an educational setting. According to this author, any plan for implementing such a system should first focus on the development of the individualized diagnostic curriculum on which the CMI application is to be designed, and then on the creation of the base data files that are to be used in the system. The planning should further be based on the design of an instructional model that defines how the components of a curriculum flow into one another, the manner in which diagnostic tests will modify or influence the instructional process, and which instructional areas will be directly reflected in the CMI program. Decisions will also need to be made as to whether the model (and the CMI application itself) will include components for continuous assessment, systematic review and assessment, and validating of mastery tests. From this perspective, the model itself and the reorganization and evaluation of each curricular area that will be necessary for the development of the CMI application are the backbones of the program's utility for both the administrator and the classroom instructor.

The ultimate success or failure of CMI depends, however, on the training and inservice options that are provided for staff and instructors and how readily they accept it. According to Gundlach:

> It is absolutely imperative to the success of CMI that great emphasis be placed on teacher training and inservice. Staff should be taught how to use an instructional model in an activity separate from the use of the computer. Then they will need to learn how the computer can provide them with time-saving, accurate reports that are based on continuously updated files. At the same time, both instructors and administrators must be trained in how to use the reports and in what each type of data specifically means. (p. 151)

The fact that computer-assisted instruction is frequently the first (and sometimes easiest) computer application to introduce into the classroom should also be kept in mind. The use of computer-managed instruction, in contrast, is likely to require a substantial number of adjustments from both students and teachers.

Examples of CMI Use in Vocationally Oriented Education

Current CMI applications in public vocational education and private industry are generally reported and examined in combination with CAI activities. A few reviews of pure CMI applications, however, do exist and can be of interest to educators.

Public Vocational Education Applications

In the vocational setting, the literature indicates that CMI applications delivered by microcomputer are used in a variety of ways. For example, Orr (1982) describes how CMI is of use to academically disadvantaged vocational students. The Florida school he observed has an Individualized Manpower Training System (IMTS). Students who enter this system are first given diagnostic tests in three areas—language mechanics, reading, and two levels of arithmetic. Within five minutes of the completion of these tests, the computer scores the tests, determines both the student's needs and the resources that are available, and then prints out a grade level profile, an individualized prescription for remediation, and statements of areas where the student already has mastery. Orr indicates that this last item gives students information about their strengths and provides built-in positive reinforcement by showing the student how much he or she already knows. Based on the remediation prescription, the student can then begin CAI studies in areas of math and English.

The CAI-delivered math instruction also has a built-in CMI component that delivers computer-administered tests as part of the CAI activity. The system is programmed to record the time a student spends on an instructional module, the number of exercises that are completed, the average number of exercises completed per minute, and the number of correct answers compared to the number of exercises attempted. The computer can store the information and make comprehensive comparisons once the training is completed.

Yonker (1982) writes about several CMI applications related to vocational education at Southfield High School in Oakland County, Michigan. He says that computers are used in four basic ways at the school—instruction, management of instruction, student and program evaluation, and general statistical use. The specific CMI applications at the school include—

- testing and scoring of task modules for the auto mechanics course;
- storing of worksheets and other informational materials that may require frequent updating or modification;
- producing class lists, lists of course objectives, and student achievement summaries;
- preparing and offering practice problems that are matched to the student's ability; and
- preparing student evaluations in a documented, customized fashion.

The use of computers in this school has given vocational teachers access to more meaningful facts, more services, more support for instruction and evaluation, and more follow-up information than ever before. Yonker indicates that by using CMI, teachers are becoming diagnosticians as opposed to being clerks, since the teachers' routine tasks can be completed with speed and efficiency.

> Those of us at Southfield High who are using computers have found that our thinking has been sharpened by the need for new programs and the proper use of those already created. We are freer to challenge time-accepted practices when we know we can put the computer's memory and storage to work for us. There is more experimental thinking and more logical thinking done when data are available and practical applications are open to us. (p. 43)

A number of authors have also written on CMI applications in specific occupational program areas—particularly in marketing and distributive education and in business and office education, and in industrial arts education. Here are a few summaries:

- Russell (1982) feels that with the microcomputer, it is feasible to develop and store computer-based instructions that are tailored to individual student needs and career goals. He suggests that training plans can be developed and printed from a list of competencies in various marketing clusters generated by the computer. Also, he suggests that by using the computer, test banks can be created and other classroom instructional management functions can be performed more easily.
- Lambrecht (1982) suggests that the microcomputer can be of value for a variety of instructional management and support activities, including testing, materials generation, student grade compilations, recordkeeping, and readability analysis of instructional content.
- Milam (1981) says that the computer can be an efficient, time-saving assistant to the teacher. Through its use, students are aware of the work they are to do for each course and the date by which they should be finished. The author suggests that a computer can be of special value to instructors who are in an open-entry/open-exit environment.

- Robinson and Johnson (1982) assert that students who will be working with computer terminals on the job need to be taught a skill called "keyboarding." They say that these students do not need to have the same high level of typing skill as those who specialize in word or data processing. However, such students would be aided greatly if they could have a "touch" keyboarding rate of at least twenty-five to thirty words per minute. The authors describe four ways in which the microcomputer can be programmed to assist with the management of this type of instruction: (1) modeling, (2) individualized goal setting, (3) pacing, and (4) differentiated practice. With such programming, the machine can provide immediate feedback to a correct or incorrect response; set goals according to the needs of individual students; time the student on a sentence or paragraph and display immediately the exact typing speed; show the increment of improvement over the previous speed and display a new rate for the student's goal; or move the student toward either speed improvement or error reduction modes of practice and instruction.

- Brook (1979) lists several ways in which the microcomputer can assist with instructional management tasks for the industrial arts educator. He indicates, for example, that the machine can be used to generate different tests according to varied educational levels and, at the same time, to produce master grading sheets for each variation. It can also be used to analyze test results and to print frequent progress reports for both teachers and students. He further suggests that the computer can be programmed to assist with the peripheral tasks of the instructional process associated with setting up and cleaning up the lab, and with maintaining the machinery used throughout the instructional period.

Private Industry Applications

From the private sector, there are a number of examples of how CMI is used to offer vocationally oriented instruction to employees. Kelvin (1981), for example, reviewed a CMI application that was used in conjunction with a CAI application at Elon College—the North Carolina training branch of the Rego Manufacturing Company in Chicago, Illinois. She reports that a CMI component was included with the CAI application that was used to offer machine operator instruction to all workers. Through this component, feedback and reports were provided to both trainees and training supervisors at the end of each training session and cumulatively at the end of all training sessions. Such data served as both the basis for evaluation of the effort and for planning further activities for the students.

Overall, Kelvin's review highlighted the fact that the use of the microcomputer enabled the workers to receive a wider spectrum of skills than if they had received on-the-job training only. Another advantage pointed out was that employees could and did use the microcomputer whenever they had free time—thus the actual amount of time spent learning new skills was actually increased.

Clogston (1980) describes a combined CAI-CMI application at the Boeing Aerospace Company in Seattle, Washington. Here minicomputers and microcomputers are used to manage the total training activity for the company. The specific application of CMI includes such tasks as preparing training forecasts and schedules for instructors, tracking training requests, preparing time changes and budget reports, developing course indexes and descriptions, and producing statistical reports and graphs of individual student progress.

After analyzing these applications, the author's overall conclusion is that the microcomputer enhances the trainer's ability to deliver instruction by increasing his or her flexibility through the use of large group as well as individual, self-paced instruction, and by allowing instruction to take place during and after work hours. (In this particular situation, employees could sign out personal computers for an evening or a weekend and continue study at home.) CMI was also found to enhance learner motivation and facilitate assessment of student progress by instructors.

The Value of CAI and CMI: A Few Opinions

From this review and synthesis of current literature, it clearly seems that both CAI and CMI are promising systems for use in academic and vocational education. However, attention still must be given to the opinions of such authors as Klassen and Solid (1981) who say that although present-day computers are headed in the right direction in terms of educational technology, they are still in a developmental stage—or a stage in which their limitations outweigh their advantages. These particular authors caution educators to consider very carefully whether present-day microcomputers—

- are suited for the educational tasks they are required to perform;
- are matched with the goals and expectations of the learning environment;
- directly affect the achievement of learning goals and expectations in a positive way;
- are simple to use;
- are easily incorporated into a variety of learning situations; and
- are cost effective for the average school and classroom.

Similarly, Milner (1980) suggests that the following caveats should be kept in mind regarding computer-based instruction (CBI) that incorporates instructional applications of both CAI and CMI:

- The implementation of CBI on either a research or a development basis requires risk-taking.
- The benefits of CBI may not be large enough to warrant computer usage.
- Implementors of CBI must be fully aware of its advantages and limitations.
- CBI may not always be a workable alternative to traditional instruction.
- Short-term payoffs should not be expected.
- CBI can be expensive.
- While CBI may well be received by students, it may not obtain the necessary support from instructors and managers.
- The purpose of CBI for a given application must be made clear.
- A certain amount of student adjustment may be needed for self-paced, individualized learning.

CHAPTER V: ADMINISTRATIVE USES OF MICROCOMPUTERS

The use of mechanized systems to assist with institutional management functions is certainly not new for those schools or districts wealthy enough to afford the services of a mainframe computer. However, for most schools and districts, it was not until the introduction of the microcomputer that the widespread use of this technology for school management became feasible.

Despite the growing popularity of this application, however, the literature related to the use of microcomputers for educational administration is not as abundant as the literature regarding microcomputer applications for classroom instruction. Nevertheless, a body of literature that explores the ways in which the microcomputer can be used for educational administration does exist. In addition, literature that offers planning and implementation advice for administrators responsible for their school's microcomputing efforts is also available. In this chapter, a synthesis and discussion of such information will be presented, along with specific examples of how microcomputers are now being used for school administration.*

Can Managers Use Microcomputers?

To determine the current value of the microcomputer for school management, one need only look at the popularity of a package such as VISICALC—an electronic "spreadsheet" program that is specially designed to assist with business and management planning. Other software programs, such as graphing packages, inventory control programs, accounting packages, and word processing systems are also clearly useful to a management structure. In fact, many of the everyday functions that school administrators must perform can be handled by software that is already on the market.

Making sure that the microcomputer is used for as many administrative functions as possible is clearly the key to ensuring the technology's efficiency and cost-effectiveness for this application. Both Haugo (1981, p. 15) and Savage (1982, pp. 338-389) address the issue of administrative and school management tasks that potentially can be automated. Arranging his applications into five major groupings that include student, personnel, facility, finance, and general applications, Haugo has developed the following list of possible school administration and management tasks for the microcomputer.

Student

Athletic Eligibility List
Attendance (Annual)
Attendance (Daily)
Class Records

*As the literature does not differentiate between vocational and nonvocational institutions, the synthesis and discussion of the literature presented in this chapter will be cast in terms of educational institutions generally.

Census (Family)
Enrollment Projection
Graduate Follow-up
Guidance Records
Health Records
Instructional Management
Mark Reporting
Scheduling Assistance
School Calendar
Student Records
Test Scoring and Analysis

Personnel

Paycheck Calculation
Payroll Reporting
Personnel Record
Salary Simulation
Staff Assignments

Facilities

Energy Management
Facilities/Equipment Inventory
Facilities Utilization
Maintenance

Finance

Accounts Receivable/Payable
Activity Accounting
Financial Forecasting
Food Service
General Accounting
General Ledger
Investment Accounting
Vendor Reports/Purchase Orders

General

Activity Scheduling
Ad Hoc Reporting
Bus Routing
Information Storage and Retrieval of Library
Circulations
Media Reservations
Mailing Lists/Labels
Project Planning and Budgeting
Statistical Analysis
Snow Removal Schedule
Word Processing

In contrast, Savage classifies such computer applications into three major groupings: selected administrative applications, quasi-administrative applications, and selected teacher-clerical applications. The first two groups relate directly to institutional administration, while those in the third group correspond to the applications most commonly associated with computer-managed instruction.

Savage's classification of administrative applications is summarized in the following.

Selected Administrative Applications

Financial

Accounts Receivable
Accounts Payable
Student Activity Accounts
Budgeting

Pupil Accounting

Daily, Monthly, Yearly Attendance Records
Daily Absentee List
Student Directories
Report Cards
Grade Distribution Studies
Student Records

Word Processing

General Correspondence
Personalized Form Letters
Reports
Curriculum Guides
Newsletters, Bulletins
Handbooks, Manuals

Personnel Accounting

Records, Reports
Directory

Miscellaneous

Inventories (Textbooks, Supplies, Equipment)
Mailing Lists, Labels
Activity Calendar
Room Utilization
Energy Utilization

Quasi-Administrative Applications

Cafeteria

Time Keeping
Bookkeeping
Payroll
Inventory
Reports
Personnel Records

Library

Accession Records
Shelf List
Card Catalog
Inventory
Utilization Records
Reports
Audiovisual Schedule
Records, Reports

Guidance

College Selection Assistance
Class Standing
Student Records
Transcripts
Test Statistics and Studies
Student Schedules
Correspondence and Reports
Student Publications
Newspaper, Magazine, Yearbook

Athletics

Inventories
Schedules
Individual and Team Statistics
Analysis of Scouting Reports

Planning to Use Microcomputers for Administration

As with any microcomputer application, the use of this technology for administrative purposes requires that a number of planning issues be considered. For example, if the school or district already has a microcomputer, the administrator will generally need to focus his or her planning efforts on identifying the daily paperwork and tasks that can most easily and readily be computerized. If the school does not have a microcomputer, however, the administrator will not only have to conduct such an "activity analysis," but will also have to consider the other applications of the microcomputer in the school, including its possible use for instruction.

Here are some of the other planning issues that Holznagel (1983) and others feel need to be considered.

- How is the hardware for the school's computing needs to be evaluated, selected, and financed?
- How is software for the school's computing needs to be evaluated, selected, and integrated into curricular and administrative tasks?
- How many actual microcomputers is the school going to need?
- Where is the microcomputer to be physically placed and housed in the school?
- How is the use of the microcomputer to be scheduled?
- How are staff members to be prepared and trained to use the microcomputer? In addition—
    - how will staff be made aware of microcomputers and of the need to teach with and about them?
    - how will staff become involved in development and implementation plans?
    - how will technical training on the use of the microcomputer be provided to staff?
    - how will work and teaching schedules be rearranged so the staff members have a chance to practice their new skills and knowledge?
- How is the community to be involved in the acquisition and implementation of microcomputers in the school?
- At what point in the curriculum will it be appropriate to offer instruction in computer literacy?

Beyond these general planning issues, administrators will also need to make decisions about specific hardware and software needs. In this regard, it is important to note that any decisions about hardware and software purchases should be made simultaneously, as a decision on the type of hardware (or brand of computer) that is to be purchased should be highly dependent on both the type of application(s) the equipment will be used for and the quality and quantity of existing software, and vice versa. For example, if the microcomputer is to be used for both instructional and administrative applications, the quality and quantity of existing software should determine the choice of a hardware system. On the other hand, if the microcomputer is to be used only for administrative purposes, there will probably be more flexibility in the decision about suitable hardware, as almost all hardware systems have some type of general school-management software packages available. Nevertheless, any hardware or software purchases should be made on the basis of a carefully developed plan that not only details the specific administrative/instructional purposes for which the microcomputer is to be used, but also takes an individual school's needs and resources into consideration.

The following sections will further acquaint the administrator with some of the important considerations and issues involved in selecting hardware and software for administrative uses.

Hardware Purchasing

Whether an administrator is purchasing a complete hardware system or is checking the adequacy of a current in-house system for administrative applications, some plan or listing of potential applications should be in the administrator's hands before purchases are made. Such a listing may determine the configuration of the system that is ultimately purchased (e.g., whether a printer is purchased; whether a modem is needed to enable the microcomputer to interface with larger or different systems; the memory size; the number of disk drives; whether graphics capabilities are needed; what kind of input devices are used/purchased; and whether sound is required).

Once such a list has been developed, attention should then be focused on such issues as—

- where to purchase the microcomputer;
- the cost of the microcomputer;
- support and maintenance staff that are available to repair the microcomputer and offer advice to the school staff;
- personnel on the administrator's staff who will be responsible for operating the microcomputer.

Software Needs

Several authors specifically address the administrator's need for software. Temkin (1981), for example, writes that a variety of good administrative software for microcomputers is already available. However, he does suggest that finding the right program for the specified application requires some patience and deliberation. To aid the administrator's search for software, Temkin includes a listing of potential software sources that an administrator can use. Among his suggestions are the following:

- Write to major textbook publishers.
- Read computer periodicals or trade magazines and journals.
- Talk to salespersons at the local computer store.
- Write to computer hardware companies.
- Speak to and/or share locally developed software with personnel in other school systems.
- Ask major software dealers if they have anything relating to school administration.
- Inform the local computer society or educational user's group about software application needs.
- Attend computer shows.
- Let others at professional meetings know about special software needs.

- Offer to work cooperatively with other school or district administrators to locate appropriate software.

- Scan mail-order catalogs and flyers.

There are also several authors who have suggested some administrative software selection criteria that are independent of any specific program category or application (Haugo 1981; Ellis 1981; Temkin 1981). Temkin, for example, illustrates a number of the more general selection criteria and guidelines. The following list summarizes his recommended guidelines.

- Do not buy a package without getting some background information on it.

- Ask about the availability of a money-back guarantee.

- Arrange to see the program in operation (preferably at another school) before purchasing.

- Be sure the instructional documentation should provide an understanding of the program. Review it carefully before purchasing a program.

- Check the format of information produced with the program before purchasing a program.

- Ask whether the cost of the program can be justified in terms of labor and time saved.

- Ask if the program publisher has a telephone service for responding to users' technical problems.

- Check for compatability between the program and available hardware.

Choosing general-purpose software. Stanley Pogrow (1982a, 1982b) has authored two articles that focus upon the selection of software for school administrative and management applications. The first of these articles looks at the possibility of using commercial, general application programs for most of a school's administrative or management tasks, such as scheduling and attendance record keeping.

Pogrow says that many of the administrative tasks facing an administrator are quite similar and follow a fairly common set of procedures. For this reason, "specific" administrative software, such as attendance or inventory programs may not be needed. Instead, he suggests that most administrative applications can be carried out with a few general application programs—software that simplifies or organizes the procedures that are common to most administrative tasks. From his perspective, there are three categories of general-purpose programs that can solve many administrative problems: (1) word processing programs, (2) electronic spreadsheets, and (3) database management systems. Specific programs within these three categories are not only inexpensive but are also available (often with training included) at most local computer stores. He suggests that there are definite advantages to using this type of application package over using the more specialized packages.

Pogrow goes on to discuss each of the three software categories in some detail. For each category, he looks at the purposes it serves within a school setting, the availability of individual programs within the general category group, and special hints for successful implementation of programs within the category.

In regard to the electronic spreadsheet category, he notes that such programs can handle tasks involving two-dimensional (rows and columns) tables filled mostly with numbers that need to undergo extensive, repetitive calculations. With these programs, a single value in the table can be changed and all related values will chanqe along with it. Such capability is of value to a business manager during salary negotiations, for example, because the fiscal impact of a proposed change in a salary schedule could be determined in seconds as opposed to days. Other applications include making budget and enrollment projections, aggregating attendance data, mapping time on task for different instructional objectives, preparing budgets, and doing inventory valuations.

Pogrow also discusses both the VISICALC and SUPERCALC programs, saying that one or the other is available for every microcomputer and that, although there are differences between the two, the differences are not significant enough to make one program clearly better than the other. The cost of these programs is minimal, and in some instances it is possible to transfer the information from the spreadsheet to a graphic display program so that results can be displayed as graphs, pie charts, or histograms.

Pogrow says the primary work in using these programs is in the creation of a model that contains headings for the rows and columns that describe the relationships between the various cells in the table. Most individuals can learn to set up their own models with about three days of training. Or, as an alternative, a model can easily be developed at a local computer store.

Scheduling and attendance packages. In his second article, Pogrow examines some of the specialized school administrative software packages available for scheduling and attendance applications. In Pogrow's estimation, there are literally hundreds of microcomputer programs available that promise to ease the task of school management. He explains that some aid in the scheduling process, others help track attendance or grades, and still others try to do all of these tasks. Because the array of programs available is bewildering to the administrator, he has established some general guidelines that can be used to summarize information and help make the selection process much easier. The guidelines include both general and specific criteria.

The general criteria are that the program must have the potential to save a substantial portion of the staff time that would be needed to do the same task manually, and that each program must perform a task that could not be done simply with a general purpose program, such as a word processor or database manager. Pogrow writes that the software programs meeting these criteria can track the process of period-by-period attendance and are actually powerful enough to schedule students individually.

Pogrow next identifies and defines specific criteria that administrators need to consider when selecting a special application package for scheduling or attendance. Among these criteria he includes such items as ease of data entry; required hardware; memory size; and peripheral equipment; price; multiple applications; program language; number of years on the market; and copyright policies and supporting documentation.

Examples of Microcomputer Use in Educational Administration

Specific examples of administrative uses of microcomputers help illustrate their wide range of potential uses. Six such examples are provided in this section. Although not all six are vocational in nature, the applications demonstrate how functional the microcomputer can be for tasks that might be part of a vocational administrator's daily routine.

- At W. P. Davidson High School in Mobile, Alabama, the microcomputer is used for a student scheduling and tracking system. School staff worked with computer specialists to develop a software package that included student data management, scheduling, and grade reporting. The program authors developed the package in several phases over a period of months. Each phase was carefully planned, tested, and revised. The package was developed on a 48K Apple II using a Corvus hard disk drive for data storage. Personnel at Davidson High School found that the software package enabled them to maintain a sophisticated management system with the microcomputer. The phases of the program presently being used have solved the problems they were designed to address beyond all expectations. The system also allows flexibility for the future, when staff members hope to add a student attendance program and routines that will allow them to sort and print data by any of the various fields in the database to generate such items as mailing labels and student lists by grade or sex (Bolton 1982).

- At Cuyahoga Community College in Cleveland, Ohio, an administrative literacy project was undertaken. Through interviews with administrators interested in microcomputers, the college's computer services staff designed a computer literacy course to encompass the following areas of interest designated by the administrators:

  - the ability to access and manipulate data from the student and financial databases;

  - office automation capabilities (word processing and electronic mail); and

  - budget preparation capabilities using interactive budget planning packages.

- The Atari 400 was used as a basis for the training. However, the configuration of the machine had to be modified to fit course requirements. This was done by making technical modifications that would allow the Atari to be used as a terminal in the college's Honeywell computer system. The results of the training have been gratifying. There has been increased awareness and use of the Student Information System. Academic administrators have improved their effectiveness in controlling and monitoring course offerings during the registration process. Also, a significant number of administrators and managers have increased their use of the electronic mail system (Holub and Wagstaff 1982).

- A small database management system was originally developed at the University of Illinois to keep records on all graduate students. However, the system's developer thought that the system was general enough to be used in public school systems for a variety of record keeping applications, including administrative data and inventories of classroom materials. The system was initially developed for a DEC timesharing computer. Later it was modified for use on an 8080 microcomputer with floppy disk drives and sequential access files. The system, called the Microcomputer System for Educational Applications (MSEA), is used in the Illinois University's secondary education department (Cox 1979).

- At the Hopewell Elementary School in the Southern Lehigh School District of Center Valley, Pennsylvania, the microcomputer is used to produce and write the Individual Education Programs (IEPs) required by P.L. 94-142. The program that the school uses allows both a regular and an evaluative IEP to be printed. It also offers an automatic print choice by which the computer goes through each pupil's file and prints IEPs in all appropriate subject areas. On a regular IEP, the computer prints (1) the name of the subject area; (2) the student's name, date, and teacher; (3) a grade (including a place for the teacher to add a narrative under the "Present Level of Functioning" heading); (4) the annual goal; and (5) specific objectives and criteria for mastery from the student's file. All objectives that the student has not yet mastered, regardless of year, are printed. The prior year's remaining objectives become the first objectives on the new IEP. The school's principal says that the microcomputers can be an effective aid in printing IEPs for handicapped students. They can also track student progress, complete the proper forms, and provide required record keeping data. The microcomputers also can release teachers from some time-consuming, repetitive tasks (Hooper 1981).

- In the Montgomery County schools in Maryland, microcomputers are used in combination with minicomputers and mainframes in a logically distributed processing application for dispensing gasoline for the school system's vehicles. This system is programmed to validate both drivers and vehicles, authorize the dispensing of fuel, maintain records of gas consumption, and substantiate claims to receive state reimbursement of the county's transportation costs. County and school officials say the system is working successfully. They are examining the possibility of installing CMI and guidance applications using the same type of distributed data processing system (Raucher 1979).

- At Willis Junior High School in Chandler, Arizona, the school's principal uses the microcomputer for three time-consuming chores: organizing personnel files, tracking student disciplinary problems, and recording the school budget. He uses a database management system for his personnel-related work to organize necessary information about the school's teachers. For his budget work, the principal uses VISICALC. He estimates that the use of the database management system saves him an estimated four and one-half hours per week (Pogrow 1982c).

CHAPTER VI: BEYOND THE MICROCOMPUTER

One of the new technological devices that provides exciting future possibilities for delivery of vocational education is the videodisc. Videodisc technologies (specifically, optical or laser systems) are already being applied to training programs both in the military services and in private industry. The videodisc allows for storage and random access to the equivalent of thirty minutes of television or 54,000 separate frames of text, photographs, or graphics. The videodisc may also be connected to a microcomputer. This allows interactive instructional computer programs to access and display a large volume of information.

A limitation of the microcomputer, when used as an instructional delivery tool, is the relatively small amount of text or graphic information that can be accessed using magnetic media. Instructional software that incorporates a large amount of graphics or text will quickly exceed the capacity of most microcomputers' magnetic disks. By combining the large storage capacity of the videodisc with the microcomputer, virtually instant access to previously unimagined amounts of information can be provided to the student. As a matter of fact, a videodisc can hold 2,000 times more graphics than the typical microcomputer floppy disk. The videodisc, however, can contain photographic images and/or television-type programming with sound. The sound track can be multiple-channel, which allows for two (or more, with some equipment) language or audio tracks to be linked with the same video. This allows for the use of bilingual educational materials.

Evidence that videodisc-microcomputer technology is practical in education and training can be seen in research currently being conducted in the military and private sector. Several companies, such as IBM and Texas Instruments, have already incorporated computer-controlled videodisc training programs into their organizations. Also, both the U.S. Army and the U.S. Navy have successfully developed and tested this type of training.

Development and production of videodiscs are more expensive and difficult than development and production of materials on magnetic media. This is primarily because videodiscs are for playback only. That is, users cannot record their own discs without very expensive equipment. The result is that materials produced for this media must be useful over a relatively long period of time or for a large group of students if the production costs are to be recovered.

At the present time, development costs for a master videodisc are slightly higher than those for a videotape of similar length—mainly because the information that will ultimately appear on the videodisc must first be recorded on and edited via videotape. Once this master videotape is complete, the information can then be transferred to a disc that will serve as the master for subsequent copies. However, videodisc-microcomputer hardware costs are still not beyond the reach of educational institutions. In 1982 a package containing an Atari computer, a magnetic disk drive, a Pioneer videodisc player, and all necessary interface electronics was available for $3,500. Individual videodiscs, in production runs, currently retail for about $20 each.

The potential that combined videodisc-microcomputer application holds for vocational training is very great. The combination of the very large storage capacity and fast random search capacity of the videodisc with the interactive capabilities of the microcomputer is potentially the most powerful educational technology in history. The hardware is already available; what is needed to render the technology useful for vocational education is appropriate software.

A related technology that has been demonstrated in prototype models is the videocube player, which is similar to the videodisc. However, instead of using a rotating disc for storage, a three-by-five-inch card is used. These cards may be stacked and automatically inserted into the player much as 35-mm slides are placed in a slide projector. Each card can hold forty-three minutes of video per slide, and projected replication costs are on the order of ten cents per card (Wood 1982).

The potential for this device is that a volume of information approaching that of the Library of Congress could be stored within the space of a normal office desk. If the software were developed properly, students could have immediate access to any section of an entire curriculum. The basic concepts of how to go about delivering vocational instruction must be completely reassessed if vocational educators are to take advantage of this powerful delivery system.

Another technology that has many applications for vocational educators is the integration of microcomputers with advanced telecommunications equipment. A modem—a device that allows digital signals to be transmitted and received by telephone cables—is available for every major microcomputer for less than $200. By connecting a modem to a microcomputer, it is possible to communicate with other microcomputers or with large mainframe computers. This allows the sharing of software or data with remote sites. It also provides access to large computer programs or memory banks through inexpensive microcomputer hardware.

Applications of this technology to vocational education might include—

- rapid dissemination of software;
- rapid gathering and processing of statistical data such as placement and follow-up information;
- establishment of networks of vocational leaders, administrators, teachers, or students who could communicate either on-line or through electronic mail; and
- development of vocational curricula within a large computer that could be easily accessed by any local institution.

Many problems related to the geographic location of institutions or students could be solved with this technology. More importantly, however, the development of inexpensive hardware to utilize telecommunications technology allows vocational educators to reexamine completely the foundations upon which the delivery and structure of vocational education rest. This technology and the other devices discussed here pose enormous potential for improving the long-term quality and cost-effectiveness of this country's vocational education system.

CHAPTER VII: SUMMARY AND RECOMMENDATIONS

Judging from currently available information and opinion, there is no question that the microcomputer is a powerful technological development that can have a very positive impact upon the planning, delivery, and management of vocational education. Given such potential, however, it is also clear that the implementation and use of this technology must be approached with some measure of caution—lest the microcomputer become more an expensive toy than a viable instruction or management tool.

To help today's vocational planners and policymakers develop an understanding of how this technology might best be utilized in the vocational setting, this chapter will summarize some of today's most appropriate applications for the microcomputer in vocational education. In addition, a number of recommendations on the appropriate roles for federal, state, and local policymakers will be offered.

A Summary of Suggested Applications for the Microcomputer in Vocational Education

The responses of the field-based experts who participated in the study and the review of the literature as reported in this document suggest that the following applications of the microcomputer are most appropriate for vocational institutions:

- Instruction in computer skills essential for an occupation
- Remediation and repetitive practice in basic skills
- Instruction in computer literacy
- Computer-assisted instruction
- Computer-managed instruction
- School administration, budgeting, scheduling, and record keeping

Obviously, a long-range plan for the use of microcomputers in vocational education programs may incorporate any or all of these applications depending on individual program needs, priorities, and funding. However, each of these applications must eventually be considered by all schools. Therefore, summary discussions on each application are presented in the following sections.

Instruction in Computer Skills Essential for an Occupation

In some occupations, actual hands-on use of computers is already essential to successful employment. This is the case in a number of business, agricultural, and industrial occupations.

For example, the increased use of computerized, numerically controlled machine tools in industry requires that students gain experience in the use of computers as a job entry skill.

This application of microcomputers is likely to meet with the least resistance from instructional staff and to make the most sense to administrators and boards of education. Advisory committees can contribute to the implementation of such instruction by recommending curriculum revision and evaluating hardware and software. Instructors' professional self-interest should motivate them to make necessary program changes in order to incorporate this type of instruction.

Remediation and Repetitive Practice in Basic Skills

Research has shown that microcomputers can provide valuable assistance in improving the basic skills levels of both youth and adults. In addition, the research surveyed for this document shows that software programs in basic skills are already available for many brands of microcomputers; thus this application should be both an effective and an economical use for most vocational institutions.

Instruction in Computer Literacy

Given present trends toward computer use in business and industry, an orientation to computing will probably become an important component of all vocational programs. However, it is important to remember that not all vocational students will need to learn to program.

Computer literacy, or a basic understanding of computer processes, promises, and limitations, can be taught without the extensive software needed for such applications as instruction in computer skills essential for an occupation or remediation in basic skills. In fact, almost any of the existing spreadsheet programs, general-purpose programs, or database management systems can easily be used to help students become computer literate. Thus this application may be one of the most logical and economical ways for a school to begin integrating the microcomputer into the vocational curriculum.

Computer-Assisted Instruction

Although a "popular" application of the microcomputer, computer-assisted instruction may present one of the most difficult applications to implement because of problems for instructors in software development, the need for extensive inservice education, and the relatively high costs involved. The opinions of the field-based experts who participated in this study and the review of the literature also reflect serious concern about the educational effectiveness of computer-assisted instruction.

It must be noted that industrial training applications of CAI have proven to be quite valuable. Such applications, however, normally focus on short-term goals and clearly identifiable topics that lend themselves well to the formats and methodologies of CAI. In light of such success with CAI, it is probable that innovative, motivated instructors may be able to develop CAI within individual programs before microcomputer technology is introduced into a whole school or school system. Administrators should therefore establish standards and procedures for CAI in advance of the introduction of the technology in order to prevent the waste of funds on ineffective CAI programs.

Computer-Managed Instruction

Computer-managed instruction is also a "popular" application of the microcomputer as the advantage of mechanized record keeping systems over manual systesms is considerable. Microcomputers make it possible to keep records of individual progress and can be programmed to test students as well as to record the test results.

Although the content of specific CMI software will be different for each different vocational program, the underlying hardware system and documentation will generally be universal throughout the school. Thus CMI can prove to be a cost-effective application in terms of both hardware and inservice training needs.

School Administration, Budgeting, Scheduling, and Record Keeping

The quantity of data and the burden that data-gathering requirements place on educational personnel make the use of a computer data management system essential because it can prevent professionals from having to work as clerks. Also, certain administrative functions (e.g., budgeting, scheduling, and record keeping) are common to all branches of education. Thus it should be economically feasible for the private sector to prepare software for such computer applications.

In terms of administration, microcomputers can function economically and effectively whether for one school, a school district, or an entire school system. In addition, the successful application of the microcomputer for administrative purposes should encourage administrators to expand the use of microcomputers within instructional programs.

Recommendations for Federal, State, and Local Policymakers

Microcomputers promise much for the improvement of instruction. Excellent examples of innovative uses abound. The growing importance of vocational education in economic development and national defense production suggests that attention be directed at the federal, state, and local levels for the effective development and use of this new technology in education. Leadership is needed at all three levels if microcomputers are to be more than a fad.

Recommendations at the Federal Level

Research is needed on the costs and effectiveness of the use of microcomputers for the educational applications identified in this chapter. The U.S. Department of Education should fund research efforts of a depth and quality necessary to evaluate the costs and effectiveness of microcomputers in education, and should also identify guidelines and standards for successful implementation of computer applications in vocational education.

In addition, legislation is needed to provide tax incentives for microcomputer manufacturers who give or lend hardware to public schools and colleges. The legislation should approve such tax incentives only for those hardware manufacturers who meet a common standard for the interchangeability of software; that is, hardware manufacturers should not receive a tax advantage for donating to public schools and colleges microcomputer equipment that can use only software that is developed by the same company or a subsidiary, or that can be used with only one brand of microcomputer.

The revision of the Vocational Education Act of 1976, now in process, could include language and funds designed to motivate and encourage the use of microcomputers in vocational education.

Recommendations at the State Level

The responsibility for leadership in the introduction of worthy innovations into public schools and colleges rests with the state leaders for such institutions. The responsibilities of such leadership are to evaluate innovations, identify the finest examples of implementation from the field, determine critical factors in replicating the success, provide motivation and leadership for inservice education, and provide funding assistance.

Excellent examples of effective uses of microcomputers are important, but experience shows that the fine examples too often remain in the institutions where they are initiated and are not transported to other institutions within either the local system or the same state. Therefore, it is vital that conferences, newsletters, inservice seminars, and other activities be strongly encouraged in order to keep vocational personnel informed of what is currently happening in regard to the implementation and use of microcomputers in the vocational institution.

Many states require the approval of textbooks at the state level before they can be adopted by local boards of education. State educational leaders should also consider identifying hardware and software that meet standards of quality and compatability.

Recommendations at the Local Level

The high costs of microcomputer hardware and software are deterrents to the implementation of this new development into our public schools and colleges. Impulse buying of microcomputer hardware without a plan for implementing the applications—including a plan for the purchase or development of software—will result in disillusionment and rejection of a very important innovation. Plans, policies, and practices must be developed through committee action and should involve school administrators, teaching staff, and representatives from business and industry in the community.

Inservice education for both school administrators and instructors will be the responsibility of local leadership with assistance from state educational leaders and universities. The scope of inservice education should relate to the applications of microcomputer technology selected for implementation as a series of inservice education efforts will be necessary to cover all applications.

Miscellaneous Recommendations

Some recommendations do not fit neatly into the categories outlined for federal, state, or local levels. These recommendations are as follows:

- Computer literacy for instructors should be addressed by all levels of planners and policymakers.
- Course content must be modified by teachers to include those microcomputer applications found on the job. Local program advisory committees must be used to incorporate microcomputers into the curriculum.

- "Passing the buck" on the issue of who should develop instructional software must cease among educators, publishers, and hardware manufacturers.
- Teachers must be willing to accept software developed outside of their own classrooms.
- A trustworthy system for software evaluation must be put in place and publicized.
- Basic research on how people learn when using a microcomputer must be done to avoid making it only an electronic "page turner." Computer literacy for administrators must keep pace with that for instructors.
- Grant programs must be developed for microcomputer software development.
- Policymakers and planners must be prepared to address other technological developments beyond microcomputers.

APPENDIX A: A GLOSSARY OF MICROCOMPUTER TERMINOLOGY

bit (binary digit): the smallest unit of digital information.

bug: an error in programming that causes faulty output. May also mean a hardware malfunction or design error in the computer or its peripherals.

byte: a basic unit of information in a computer. Commonly consists of a sequence of eight binary bits, usually handled as a unit. One byte usually represents one character.

cassette recorder: a device for storing information. Because most computers lose the information stored in them when they are turned off, a means of keeping the information is necessary. Binary information is stored on a cassette tape by first converting it to audio signals and recording it on the tape. This method of storage is slower than disks.

central processing unit (CPU): the CPU controls what the computer does. It includes three main sections: arithmetic, control, and the logic elements. It performs computations and directs the functions of the computer.

character: single items that can be arranged in groups to stand for information. There are two forms: (1) numbers, letters, graphic symbols, etc., that can be understood by human beings, and (2) groups of binary digits that can be understood by the computer. A character is usually represented by one byte.

chip: a small, flat piece of silicon on which electronic circuits are etched. As the heart of a microcomputer, this microprocessor contains all the circuitry needed to carry out computer operations.

coding: developing a set of computer instructions or translating "human readable" material into "computer readable" material.

command: an instruction given to the computer through an input device or peripheral.

compatibility: there are two types of compatibility—hardware and software. Hardware compatibility means that various components (printers, disks, keyboards, etc.) may be directly connected without intervening electronic devices and that all components use the same baud rate (i.e., data transmission speed), word length, and other technical aspects in order to communicate. Software compatibility refers to the ability to run programs on a variety of computers without changing the program language.

computer: a device designed for the input, storage, manipulation, and output of symbols (digits, letters, punctuation). It can automatically follow a step-by-step set of instructions to manipulate information. The set of instructions and the information on which the instructions operate usually

Terms adapted from Marcella R. Pitts, *The Educator's Unauthorized Microcomputer Survival Manual.* (Washington, DC: The Council for Educational Development and Research, 1983).

vary from one moment to another. The difference between a computer and a programmable calculator is that the computer can manipulate text and numbers; the calculator can manipulate only numbers.

courseware: a combination of content, instructional design, and the physical program (software) that causes a computer to complete instructions.

CRT: acronym for cathode-ray tube—a device in which cathode rays are beamed onto a fluorescent screen, resulting in luminous spots.

data: the information given to or received from a computer.

debug: the process of finding and correcting errors in a program that might cause problems or provide inaccurate information.

disk (disc): magnetic-coated material in a 5- or 8-inch record-like shape on which information and programs are stored. Since the information is stored randomly, it can be accessed faster than on cassette storage. Sometimes called diskettes or floppy disks.

floppy disk (disc) drive: a device for storing masses of information on a rotating, flexible, magnetic-coated plastic disk that is similar to a 45 rpm record. Information can be stored and quickly retrieved. Unlike cassette tapes, (on which all information must be scanned), the disk allows the user to go to any section of the disk without searching through intermediate information.

hard disk (disc) drive: a peripheral device for storing programs or other information on disks made of rigid aluminum, coated with a magnetic recording surface. The most common form of storage on large computer systems.

hardware: the physical components of a computer system, consisting of the central processing unit plus all peripherals.

Input: information going into the computer or into a peripheral device. The same data may be output from one part of the computer and input to some other part of the computer.

Interface: an electronic circuit that connects the CPU and a peripheral device (disk drive, etc.), permitting the flow of data back and forth.

language: a format that allows a programmer to communicate more efficiently with a computer where predetermined commands will give requested actions. BASIC is one of the most popular languages. A language is a defined group of representative characters or symbols, combined with specific rules necessary for their interpretation. The rules enable an assembler or compiler to translate the characters into forms (such as digits) that are meaningful to a machine, system, or a process.

memory: the integrated circuit of a computer that can execute instructions. Serves as the "brains" of the central processing unit.

microcomputer: a computer whose central processing unit is a microprocessor.

microprocessor: an integrated circuit that executes instructions. Also, a central processing unit on a single chip.

modem: an abbreviation for "MOdulator-DEModulator." It is a device that permits computers to transmit information over regular telephone lines.

monitor: a video display unit that uses a cathode ray tube (CRT) to generate characters. It looks much like a normal TV set; however, the monitor has a much higher degree of resolution, which permits that clear formation of very small characters on the screen.

off-line: refers to the location of data on storage devices that are not immediately accessible to the computer. Data stored on magnetic tape, punched cards, or paper tape must be loaded into on-line storage to be available to the computer.

on-line: refers to the location of data on storage devices that are immediately accessible to the computer. Usually on-line data are stored on discs, in RAM, or in ROM.

output: information coming from the microcomputer to a display unit, such as a CRT or printer.

peripheral device: a device such as a printer, disk drive, etc., which is an additional computer component.

printer: a peripheral device that accepts output data from the microcomputer and prints it on paper. Printers are defined as impact or nonimpact. Impact printers strike the paper by a ribbon like that of a typewriter. Nonimpact printers form characters by electrical charges or by spraying ink.

program: a series of instructions to the computer that causes the computer to perform an operation.

RAM (Random Access Memory): the computer's general purpose memory. RAM may be written into or read from the central processing unit. RAM can be erased and reprogrammed by the programmer as frequently as necessary. It is volatile: that is, it disappears when power to the computer is turned off.

ROM (Read Only Memory): a circuit where data or instructions are programmed at the time of manufacture. ROM cannot be erased during normal operations. ROM is fixed, not volatile.

software: refers to programs and accompanying documentation. Software is stored on tape cassettes or disks when not being used by the computer. The computer reads the software into its memory in order to use the programs.

spreadsheet: a computer program (presented in table form) that allows the user to manipulate easily large amounts of figures and other data.

storage capacity: the quantity of bytes a storage unit can hold. It is usually expressed in kilobytes (i.e., "thousands" of bytes).

terminal: a peripheral device that facilitates human communication with a computer. Usually consists of a keyboard with alphabetic and numeric characters coupled with a printing mechanism or a CRT. One enters information via the keyboard; the computer responds via the printer or CRT.

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