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ABSTRACT

Based on a comprehensive review of the existing research reinforced by consultation with a panel of experts, this report documents the impact of computers on many aspects of elementary and secondary school operation--e.g., uses to which computers are put, student performance and attitudes, and teacher atttiudes--and also on postsecondary education. Discussions of computer uses in elementary and secondary education cover current use patterns; factors influencing computer use; regional/state, socioeconomic, and urban/rural use differences; and uses in special, vocational, and bilingual education. Projected computer use during the next decade is also discussed. Effects of computers on student academic performance and attitudes are explored via background information on current school practices, a review of the literature on the effects and effectiveness of computer assisted instruction and computer managed instruction, and projections of effects which computer use in schools may have on students. An assessment of the importance of young peoples' computer use in school for their postsecondary education prospects is also presented; this includes reviews of ways in which computer literacy is viewed in the context of computers in education, impact of computers on postsecondary education institutions, and computer literacy requirements for college entrance. Policy issues are addressed, study methodology is reviewed, and expert panel members are listed. An extensive reference list is provided. (MBR)

Research Report

USES OF COMPUTERS
IN EDUCATION

by

EDUCATION TURNKEY
SYSTEMS INC

April 1985 RR-85-07

NCEP

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The conclusions and recommendations in this report are those of the contractor and do not necessarily reflect the views of the National Commission for Employment Policy or any other agency of the Federal Government.

PREFACE

Computers have been entering American schools at a phenomenal rate: the number of microcomputers in elementary and secondary schools increased from fewer than 30,000 in 1981 to more than 630,000 three years later. This rapid growth led the National Commission for Employment Policy to ask how computers are being used in schools, how effective this use is, and what their future use is likely to be.

Some of the findings in this report indicate that computers can be effective tools for educating children. To date, however, their potential is largely unrealized. Schools generally have not met three conditions which must exist for computers to be successfully integrated into schools: good advance planning for computer use, adequate staff training, and high quality software.

Still, there are signs that the situation is changing. Many school districts and States are now planning how to use computers effectively and developing training for teachers who will administer their use. There are also indications that the overall quality of available software is improving.

The Commission's goal in issuing this report is to encourage education policymakers at all levels -- including the classroom teacher -- to continue to move in the direction of effectively integrating computers into schools. By presenting what is known about how this equipment is used in schools and the effectiveness of computers in specific educational contexts, and by transmitting strategies to improve computer use, the Commission is hopeful that its goal will be met.

This st y is one of several dealing with the effects of computer-based equipment on the job market. Other Commission Research Reports on this topic concern how computers affect the number and types of jobs that will exist over the next ten years, and the extent to which youth and adults will have the necessary education and training that must accompany the successful introduction of computers into the workplace.

This series of reports was designed by Carol Jusenius Romero, Sara B. Toye, and Stephen E. Baldwin of the Commission staff, who are also supervising all aspects of the project. This team worked closely with TURNKEY in organizing and presenting th informat contained in this report. It should be emphasized, however, that the factual information discussed as well as the issues raised do not necessarily reflect the views of either the Commission or the Commission staff.

The Commission expresses its appreciation to TURNKEY for this work and for their good-natured and careful responses to points raised by the Commission staff.

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EXECUTIVE SUMMARY

In the past ten years, computer use in schools has changed dramatically. No longer do schools use computers only to process administrative data. Since the advent of the microcomputer, students at all levels have begun to use computers both as an object of instruction and as a learning tool. This influx of computers has had, and will continue to have, major impact on many aspects of school operation, including the uses to which computers are put, student performance and attitudes, teacher attitudes, and post-secondary education.

It should be emphasized that no responsible researcher or practitioner has implied that computers will solve our country's educational problems, will replace good teachers, or are, in any way, an educational panacea. Computers are to education what they are to other disciplines -- extremely useful tools for both the management and delivery of services.

A. COMPUTER USE IN EDUCATION

The personal computer is so new that a major 1976 study of computer activities in schools did not mention the word "microcomputer". By June 1984, approximately 630,000 microcomputers were in the public schools. Moreover, 98 percent of school districts with enrollments of 600 or more had at least one microcomputer.

Existing use of computers in schools can be classified into the following categories:

- Computer-Assisted Instruction (CAI), where the student interacts directly with the computer. The various modes of CAI include drill-and practice, tutorials, simulations, and problem solving.
- Computer-Managed Instruction (CMI), where the computer serves as a support tool for the teacher and principal.
- Education Administrative Applications, including attendance, scheduling, test scoring, data analysis and reporting, and the development and updating of individualized education plans (IEPs).
- Tool Applications/Instruction, including word processing, spread sheets, graphing, data base managers, etc.
- Object of Instruction, including orientation and programming.

Computers, in general, have been used for relatively short periods of time during the school week. As elementary schools obtain more microcomputers, more students are given access to them. In secondary schools, on the other hand, an increase in the number of microcomputers finds more intensive use by approximately the same number of students. The typical microcomputer is used in elementary schools for an average of 11 hours per week and in secondary schools for an average of 13 hours per week. About one-quarter of the elementary schools and one-fifth of the secondary schools use their microcomputers for less than one hour per day. Less than one-quarter of the computer-using elementary students use their microcomputers for more than 30 minutes per week. Even at the secondary level, nearly 40 percent of the computer-using students get no more than one-half hour per week of computer time.

Apart from general introductions to computers, programming has been the most prevalent computer activity in secondary schools. In elementary schools, drill-and-practice has been the most often employed application of microcomputers.

In the late 1970s and early 1980s, the initial use of microcomputers in public schools was essentially a "grass roots" movement led by school staff -- especially science and math teachers who were computer buffs. This movement has, in recent years, been bolstered by parents who want their children to have access to computers in school. Throughout the 1980s, educational use of computers has also been significantly influenced by vigorous promotion through advertising in education journals and conferences and by the rapid decline in cost of hardware in relationship to computing power. During the last two years, state education agencies have increasingly encouraged the use of microcomputers in public schools.

Regional differences in computer use appear to be less pronounced than differences among states. Indeed, such regional patterns are not as noteworthy as they were four years ago when the north central states had the highest ratio of microcomputers to students. State-level policies have influenced the use of microcomputers at the local level, especially in states where the state education agency has a traditionally centralized role in areas such as certification, state-wide purchasing, textbook adoption, and state-wide telecommunications.

In the last four years the computer gap between poor and wealthy school districts seems to have decreased. It is not clear, moreover, to what extent -- or, indeed, whether -- there are current differences between wealthier and poorer districts with regard to the presence of computers. While some research indicates that wealthier districts are much more likely to have microcomputers than poorer districts, other studies suggest that disadvantaged students in schools which receive money under Federal programs had more access to microcomputers than did students in schools not receiving Federal aid.

The equity/access issue is evolutionary; some believe it is in a transition phase today and may, over time, resolve itself. Paradoxically, during the late 1960s computers were looked upon as a means to provide quality education opportunities for all students. Now, because of the availability of computers in wealthy schools and in homes of middle- and upper-income families, the limited availability of technology has become an issue itself.

Some of the best documented differences in the use of computers in education are those between urban and rural districts. Many rural districts can not support quality progams in some areas because of the lack of specialized teachers, high teacher turnover rates, and great distances between schools. Computers, in combination with telecommunications technologies, have proven to be extremely valuable in addressing these rural needs. Urban school systems often face technology-related issues which are vastly different from those of rural schools. Instructional use of computers in urban schools focuses primarily on the computer as the object of instruction. Moreover, existing bureaucratic infrastructures in urban school districts have often made it difficult for them to implement new microcomputer functions.

The use of computers has been greater in special education than in the other "thin" educational markets (e.g., bilingual education, vocational education). As many as 150,000 microcomputers are being used in special education and gifted-and-talented programs for a combination of instructional and administrative functions. Several factors have contributed to the rapid increase in the instructional and administrative use of microcomputers in special education:

1. passage of the Education for All Handicapped Children Act;

2. increased attention from private courseware developers, electronic publishers and equipment vendors;

3. potential economies resulting from the high costs of providing services to handicapped students;

4. heightened pressure from parents who are becoming more aware of the availability of adaptive devices for handicapped students; and

5. significant emphasis from the U. S. Department of Education.

Approximately 80,000 microcomputers were being used for vocational education in public schools and in vocational tech centers during the 1983-84 school year -- only about ten percent of total education use. In terms of vocational groups, microcomputers were used most intensively in business education, industrial/technical education, and agricultural education. Most experts believe computer use in vocational education will continue to be lower than in education generally.

Relatively little is known about the current use of computers in bilingual programs or education programs for students with limited English proficiency (LEP). Introductory computer courses for LEP students are, for the most part, provided at the junior high and senior high levels. While some schools teach computer programming, most downplay the need for computer programming and focus upon orientation, awareness, and application. Most introductory computer courses and CAI applications occur in the areas of math and science.

It is projected that the number of microcomputers in public schools will grow to nearly three million by 1990 and that, by the end of the decade, annual school software sales will surpass annual hardware sales to schools.

Future computer use in schools depends on the degree to which school decision makers take the necessary initiatives to use technological advances effectively. Virtually all experts agree that the initiatives with the greatest potential impact are:

- Active Planning -- For technology to be used effectively in schools, its implementation must be systematically planned.

- Comprehensive Staff Training -- Training of teachers and administrators must cover the broad spectrum of technology issues and must focus on individualized instruction.

- Centralized Control -- The convergence of telecommunications and computers suggests that the full benefits of technology can best be realized through more centralized control of computer operations.

- Institutional Reform -- Other institutional changes, including incentives for staff productivity, flexible scheduling, and revised staff certification will greatly enhance the probability of effective computer use in schools.

B. PERFORMANCE EFFECTS

The effects of computers on student performance and attitudes are surrounded by a number of complex issues relating to teachers' attitudes toward technology, the quality of educational software, and the implementation variables associated with adopting CAI and CMI in schools. In addition, the growing educational use of home computers appears to be having an impact upon computer use in schools.

Although the availability of hardware is rapidly increasing, student contact time is increasing at a slower pace. The typical elementary school student spends only about 20 minutes per week on a computer; the typical secondary student spends about 45 minutes per week on a computer. One reason for this apparent lack of use is that only a small percentage of the teachers in microcomputer-using schools are using the hardware. In most schools, only one or two teachers are regular users of computers. It is generally agreed that more time needs to be spent on any learning task to produce a positive effect on skills or knowledge mastered. Thus, the amount of time a student spends on CAI may have a considerable effect on the benefits received. Some experts believe that using the computer for 20 minutes per week is so brief as to make little difference in learning outcomes.

Within local school districts, there are noticeable differences in computer use by grade level. Sixty-four percent of the elementary schools use computers to teach computer literacy or computer science compared with 85 percent of the secondary schools. On the other hand, the use of drill-and-practice at the elementary level exceeds its use at the secondary level -- 59 percent to 31 percent.

In general, elementary schools use computers most frequently in math, followed by language arts, reading, computer programming, social studies, science, and art. Math use has ranked highest over the last three years, but use in reading and language arts has increased. Secondary schools use their computers most frequently in computer science, followed by math, business subjects, and general science.

A movement which is paralleling efforts of schools to use computers to enhance instruction is the use of home computers by parents to improve the education of their children. Educational use of the computer in the home is rapidly approaching the more common entertainment uses. Home computers could increase the achievement gap between middle and lower income groups. If the growth in home computers continues, it is likely that parental pressure for cooperation between school and home computer-based instruction will continue to increase.

There is substantial evidence that computer-based education can have important positive impacts on both the performance and attitudes of specific types of students under certain conditions.

When compared to traditional instructional approaches, computer-based instruction has been found to reduce substantially the amount of time needed for the average student to master similar objectives. Findings from investigations at both the elementary and secondary levels reach similar conclusions. Younger students appear to complete material faster on computers than off -- occasionally as much as 40 percent faster. Secondary students showed savings in time for student learning of as much as 88 percent.

Positive effects of computer-assisted instruction (CAI) have been found in such pervasive areas as student achievement, attitudes, and social relations.

- CAI provides students with individualized instruction which they often fail to receive in a large classroom setting.
- The subject areas where CAI is most effective are: science and foreign language, mathematics, and reading/language arts.
- CAI appears effective when aimed at specific student body groups (e.g., high- or low-achieving students); however, lower achieving students require a longer period of time with CAI than do average or above-average students.
- When CAI is fully integrated into the curriculum, it is more effective.
- Positive effects increase when the proper setting and scheduling are established (i.e., flexible scheduling, effective teacher training, principal support, individualized pacing).
- Student attitudes toward CAI and familiarity with it have a substantial effect on CAI's usefulness.

In general, it appears that well-implemented CAI programs consistently produce statistically significant achievement gains when compared with control groups and/or previous learning rates of students.

Computer-managed instruction (CMI) has also shown many positive effects. Indeed, many CAI applications are supplemented by such CMI applications as student program monitoring. A form of individualized instruction, CMI (when used directly with students) allows learners to pace themselves, work independently, and make their own choices. Because children in the elementary grades may not have developed the skills and motivation for these requirements, computer-managed instruction has had the greatest impact at the higher grade levels.

Teachers' attitudes toward computer-based instruction and management have implications not only for how computer-based instruction will affect students but also how teachers could influence the design and development of programs by the software publishing industry.

Teachers' attitudes toward the use of computers with low-achieving students are typically positive when implementation efforts occur in an organized manner. Although some school staff can initially be intimidated by the presence of new computer equipment in classrooms, their attitudes often become more positive with time. Teachers and administrators tend to view computers in a positive light when computer-based learning packages are integrated with regular curriculum materials. There is emerging evidence that educators' attitudes are moving in a positive direction and seem to be related to exposure and familiarity with computers.

Current research findings clearly indicate that computer-based instruction can increase student achievement in certain areas when quality courseware is used and when the programs are planned and implemented in an effective manner by school staff.

It can be anticipated that, in the next few years, the use of computers will have a number of important effects on the performance of students:

1. In the last third of the decade, the relative effectiveness of computer-assisted instruction will increase dramatically in well-implemented instructional interventions with specific populations. As sophisticated courseware simulations, particularly at the secondary level, become available during the last third of the decade, students, parents, teachers, and administrators will realize the opportunities technology provides for performance-based measures of student mastery of concepts, critical thinking skills, etc. By the end of the decade, measures of student performance will become performance- or skill-based, using the computer to assess skill mastery.

2. Positive student attitudes will deteriorate over the next few years as the novelty effect of the computer wears off. Student attitudes toward computer-assisted instruction in the long run will be a function of the quality and type of software that is available in schools. Indeed, attitudes toward school-based CAI among students, who have access at home to more varied and higher quality software, may deteriorate for at least two years, until higher quality software becomes accessible and affordable to schools.

3. By the end of the decade the ratio of microcomputers to students will be as high as one computer for approximately 20 students. This ratio will, however, become less meaningful, as the computer itself will become relatively transparent in telecommunication and videodisc configurations and as students have greater computer access in other environments. Student time usage patterns will be considerably different from those

currently observed in schools. The distinction between formal education and informal learning will become blurred as students will increasingly have access to computers both during school hours and after school.

By the end of the decade, the nature of the equity problem will be more qualitative (e.g., the types of courseware available to certain groups) than quantitative (e.g., numbers of students with access to computers). Although the numbers of students using computers will give the appearance of "equal access time", a more subtle form of inequity may exist with computer technology and applications highlighting unequal treatment of students. Examples of such imbalances are: (a) limiting slower students to using only drill-and-practice software and not exposing them to more sophisticated learning activities; and (b) the low proportion of cultural minorities and limited English proficient (LEP) children who use computers for learning activities.

If effective implementation of computer-based education is to occur, the general perception of the teacher's role will have to change from that of a deliverer of instruction to one of a manager of the learning process. During the remainder of the decade, as a result of state or district policy, technology will be viewed as an element of staff productivity. It will be increasingly used to measure and evaluate staff performance as a basis for career ladder schemes (including merit or incentive pay) presently being planned or implemented in approximately 25 states. Concurrent with this role change will be increased staff differentiation with specialized roles for aides, "media planners", and new positions which will emerge.

C. COMPUTER LITERACY AND POST-SECONDARY EDUCATION

Both the concept and definition of computer literacy have changed dramatically during the last eight years and can be expected to continue to change over the next decade. Moreover, the concept of "computer" literacy will be replaced by "technology" literacy as the distinctions among computers, telecommunications, and other information technologies blur. The factors responsible for the changing nature of the concept include the following:

- advances in hardware technology;
- improvements in software, which expand their range of applications and their ease of use;
- maturation of school staff and students in the use of computers;
- the osmotic effect of the increasing proliferation of microcomputers in business, homes, and society generally; and
- policy initiatives undertaken by state education agencies in the area of accreditation and suggested/mandated competencies for students as graduation prerequisites.

In 1977, fewer than ten school districts had formal computer literacy courses with guidelines and objectives organized in a structured curriculum. In recent years, a number of states have begun to address the concept of computer literacy from a policy perspective and to influence local implementation of computer literacy courses through guidelines, standards, and graduation requirements. Although schools are being encouraged to standardize computer literacy, the establishment of specific computer literacy standards assumes that computer-related technology is static. Policy makers need to accept the changing nature of the technology and to develop practices consistent with adaptation to change.

At present, only a few dozen universities are actively placing computers in the hands of students; hundreds more are exploring such possibilities. Because high school seniors are increasingly being prepared to use computers, they are demanding more ready access to computers in college. Many colleges have plans to create networks of microcomputers on their campuses in order to increase the computing power available to students and to increase communication among students and faculty.

It is difficult to assess the number of college departments that now require computer-related skills for entrance. Some research indicates that computer-related entrance requirements do exist for some departments within colleges; however, overall admission requirements are far less likely to occur. Most institutions require neither a knowledge of the history of computers and their social implications, nor an ability to write programs. This is congruent with the changing definition of computer literacy occurring in elementary and secondary schools. Most institutions believe that incoming college students should have improved backgrounds in reading, writing, and mathematics skills.

In addressing the national concern about the quality of post-secondary education, many educators and representatives from business and industry view the computer as basic to an understanding of the full range of procedures that may be applied to organizing information and solving problems in diverse fields. Future college students will profit from preparation that reflects the broad and changing application of computer technology, including:

- a basic knowledge of how computers work and of common computer terminology;

- some ability to use the computer and appropriate software for:

  - self-instruction;
  - collection and retrieval of information;
  - word processing (including the development of keyboard, composition, and editing);
  - modeling, simulations, and decision making; and
  - problem solving, both through the use of existing programs and through development of one's own programs;

- an awareness of when and how computers may be used in the academic disciplines and various fields of work, as well as in daily life; and

- some understanding of the problems and issues confronting individuals -- and society generally -- in the use of computers, including the social and economic effects of computers and the ethics involved in their use.

The number of computers for student use at institutions of higher education are likely to increase as rapidly as they are in elementary and secondary schools. The requirement that college students be able to use computers is unlikely to be reflected in admission policies; rather it will be manifest in policies that encourage students to use microcompters in their studies.

D. POLICY ISSUES

As the growth of computer technology continues, Federal, state, and local officials will face a number of important policy issues. Among the strategies that might be useful in addressing these issues are:

- encouraging effective use of computers in education through dissemination of information on effective use (including research findings and exemplary practices) and targeting such use on specific student populations;

- ensuring the availability of software by supporting software development and facilitating the aggregation of markets which, by virtue of their small size, cannot support such development on their own;

- addressing the problem of equal access to computers by carefully studying any imbalances which exist and targeting initiatives on special needs population;

- expanding staff development and training through a combination of extensive new training initiatives and enhanced existing programs; and

- fostering enlightened debate on the meaning and importance of computer literacy.

I. INTRODUCTION

In the past ten years, computer use in education has changed dramatically. No longer do schools use computers only to process administrative data. Since the advent of the microcomputer, students at all levels have begun to use computers both as an object of instruction and as a learning tool.

In 1981, there were fewer than 30,000 microcomputers in America's schools. By 1984, there were more than 600,000 and by the end of the 1984-85 school year, the number will go over one million. It is expected that, by the end of the decade, nearly three million microcomputers will be used in our nation's schools.

This influx of computers has had, and will continue to have, a major impact on many aspects of school operation, including the uses to which computers are put, student performance and attitudes, teacher attitudes, and post-secondary education. This study has attempted to document these impacts and project future effects, through comprehensive review of existing research and through consultation with a panel of highly respected experts. Appendix A summarizes the project's methodology and lists the Expert Panel (whose opinions are frequently cited in this report).

This project has not involved the conduct of new research. Rather, its goal has been to review and synthesize relevant research from a wide range of sources and to draw appropriate conclusions from it. Because of the rapid pace of technological change, research often becomes outdated before its findings can be published. As a consequence, much of the existing research is based on hardware not representative of current technology. Nearly all studies of educational computing more than four years old investigated programs using large, mainframe computers. While such research can provide some interesting data, it does not yield much detailed information on educational capabilities of today's smaller, more powerful, and more student-controlled microcomputers. Similarly, current software provides a range of computing capabilities not readily available only a few years ago. Thus, it was found that different researchers often studied substantially different things. Some studies addressed only computer-assisted instruction (CAI), while others considered a broader spectrum of educational computer applications. The resolution of such nonuniformities and conflicts was achieved through the technical judgment of the project team, advice from the Expert Panel, and consultation with NCEP staff.

The changing nature of the technology has made it difficult for researchers to conduct the kind of studies which would demonstrate relationships between school computer use and such factors as student performance, staff attitudes, cost savings, college admissions, and post-secondary employment. Indeed, some research suggests that positive results in computer-based educational programs are, in large part, attributable more to careful planning, staff training, and structuring of the curriculum than to the computer itself. Many of the conclusions drawn in this report are based upon proxy measures and the reasoned judgment of the project team and the Expert Panel.

It should be emphasized that no responsible researcher or practitioner has implied that computers will solve our country's educational problems, will replace good teachers, or are, in any way, an educational panacea. Computers are to education what they are to other disciplines -- extremely useful tools for both the management and delivery of services.

Chapter II of this report presents a detailed discussion of computer use in public schools. It describes the characteristics of classroom computer use -- by function, by subject, by type of user, and by target population -- and projects the ways in which computers will be used in schools in the coming years. Chapter III explores the effects of computers on students and teachers, addressing the contrasts between computer-assisted and computer-managed instruction. Chapter IV examines the concept of computer literacy and its impact on students' prospects for post-secondary education. The fifth and final chapter summarizes some of the policy issues which surround educational uses of computers.

II. COMPUTER USE IN EDUCATION

The number of computers in America's schools has increased greatly in recent years and will grow even more in the years to come. This chapter of the report presents information on the use of computers in elementary and secondary education. Specifically, this chapter has two sections: the first describing current computer use in education and the second projecting future use.

Data presented in this chapter have been gathered from a wide range of existing research sources, including dozens of research, marketing, and development reports. While we have taken great care to verify the accuracy and availability of data, we recognize that, for a variety of reasons, definitive statistics are often elusive. Among these reasons are: (a) the rapid rate of technological and market changes that can make even the most carefully researched data obsolete after only a few months; (b) survey data on computers often use different definitions; and (c) because of decentralized purchasing and outside contributions of hardware and software, school officials often do not know how existing equipment is being used.

A. CURRENT COMPUTER USE

This section summarizes various important elements of the current uses of computers in education. Specifically addressed are the extent and nature of schools' use of computers, factors influencing current computer use, aspects of decision making regarding computer use, and differences in computer use among different types of schools and school settings.

1. GENERAL EDUCATION

As used in this report, the term "general education" refers to all education programs operated by public schools; within this general category are education programs for special needs populations. It represents the largest component of school activity and has, therefore, felt the greatest impact of technology.

a. Current Computer Use

The personal computer is so new that a major 1976 survey of computer activities in schools did not mention the word "microcomputer".[1] By June 1984, approximately 630,000 microcomputers were in the public schools.[2] Moreover, 98 percent of school districts with enrollments of 600 or more had at least one microcomputer.[3] While these numbers are impressive, they tell us very little about how the machines are used or how well they are used. Only by delving deeper into the subject is one able to develop a picture of computer use. This section will review the ways computers are used in the schools and the extent of these uses.

Existing use of computers in schools can be classified into the following categories:

- Computer-Assisted Instruction (CAI), where the student interacts directly with the computer: The various modes of CAI include drill-and-practice, tutorials, simulations, and problem solving. CAI courseware can be used to: (a) supplement regular instruction; (b) provide enrichment (e.g., educational games) for students; and (c) provide partial or total curricula in content areas where CAI is used in lieu of conventional basal text and curriculum materials.

- Computer-Managed Instruction (CMI), where the computer serves as a support tool for the teacher and principal: CMI systems can provide the following capabilities: diagnose learning difficulties, prescribe appropriate learning materials and activities; monitor student progress in small group or individualized learning situations, generate and score tests for individual students, manage the curriculum process for individual students, and provide reports on individual students or groups of students. Most CAI curriculum packages are augmented by CMI systems.

- Education Administrative Applications, including attendance, scheduling, test scoring, data analysis and reporting, and the development and updating of individualized education plans (IEPs) required by law for handicapped students. While many education administrative applications on mainframe computers are relatively comprehensive, including two or more of the above functions, most of the administrative applications on microcomputers are single purpose.

- Tool Applications/Instruction, including word processing, spread sheets, graphing, data base managers, etc.

- Object of Instruction: In many introductory computer courses which focus primarily on awareness and orientation, a computer may not be required; however, in situations where such courses include computer programming, computers are often required for hands-on experience and programming. The concept of computer literacy is addressed in detail in Chapter IV.

Presented below is a discussion of each category of educational computer use.

During the early 1980s, virtually all commercially available courseware was used for computer-assisted instruction in a drill-and-practice mode. Nearly 85 percent of the courseware was supplemental; only a few commercial packages were curricular in nature (e.g., PLATO, Computer Curriculum Corporation), mostly in mathematics. Of the 7,000 courseware packages recently evaluated by Educational Products Information Exchange (EPIE), 75 percent were classified as drill-and-practice; approximately five percent were considered to be simulations and tutorial.[4]

Computer-managed instruction represents only ten to 20 percent of current computer use in schools. While CMI represents a cost-effective use of computers at the present time, its use lags CAI and introductory computer courses largely because of: (a) the amount of staff training in individualized instruction techniques required for effective use; (b) greater vendor advertising of CAI because of the larger potential market; and (c) the lack of commercially available comprehensive CMI packages. Since the beginning of 1985, however, several major publishers have announced new "textware" packages which incorporate both management and instructional components into basal text series.

Administrative uses of microcomputers have only recently begun to emerge as software becomes available and school data processing units accept microcomputers. Indeed, approximately 80 percent of existing administrative applications are of a single purpose nature.[5]

Computer use in tool applications increased dramatically in 1984. The first state-wide purchase of software in the country was a secondary-level tool application package in West Virginia. A recent survey of deaf-blind institutions indicated that word processing packages were the most widely used software among the sample of schools.[6]

Perhaps the greatest current use of microcomputers in education is in classes where the computer itself is the object of instruction. At the elementary level, most teachers indicate that their purpose for having a computer in the classroom is to teach students how to use computers, as much as it is to use computers as an instructional tool.

The most comprehensive study[7] of the extent of computer use in schools indicated that the machines, on average, were used for relatively short periods of time during the school week and per student. This study further indicated that, as elementary schools obtain more microcomputers, more students are given access to them. In secondary schools, on the other hand, an increase in the number of microcomputers finds more intensive use by approximately the same number of students. It should be emphasized that much of these data are at least two years old and may not reflect the changes wrought by the great influx of microcomputers into the schools since 1982.

This survey of computer use during the 1982-83 school year found that at the elementary level, the average microcomputer is used by students or teachers for 11 hours per week and 13 hours per week at the secondary level (out of a school week which is typically 30 hours). Estimates of student use do not include use of the equipment to play games unrelated to classroom work. Exhibit II-1 shows the intensity with which the typical microcomputer is used each day in elementary schools. As Exhibit II-1 shows, about one-quarter of the elementary schools and one-fifth of the secondary schools use their microcomputers for less than one hour per day.

Similar data for student microcomputer use, as depicted in Exhibit II-2, show that less than one-quarter of the computer-using elementary students use their microcomputers for more than 30 minutes per week. Even at the secondary level, nearly 40 percent of the computer-using students get no more than one-half hour per week of computer time.

Exhibit II-3 indicates the median amount of time students spend on various computer activities in which they are involved. Apart from general introductions to computers, programming has been the most prevalent computer activity in secondary schools. In elementary schools, drill-and-practice has been the most often employed application of microcomputers.

EXHIBIT II-1

INTENSITY OF MICROCOMPUTER USE*

NUMBER OF HOURS MACHINES USED	ELEMENTARY SCHOOLS	SECONDARY SCHOOLS
MORE THAN 5 HOURS PER DAY	13%	20%
3.1 TO 5.0 HOURS PER DAY	25%	21%
1.1 TO 3.0 HOURS PER DAY	36%	39%
ONE HOUR PER DAY OR LESS	26%	20%

EXHIBIT II-2

STUDENT MICROCOMPUTER USE*

NUMBER OF HOURS STUDENTS SPEND	ELEMENTARY SCHOOLS	SECONDARY SCHOOLS
MORE THAN ONE HOUR PER WEEK	2%	37%
31 TO 60 MINUTES PER WEEK	21%	26%
16 TO 30 MINUTES PER WEEK	45%	15%
15 MINUTES PER WEEK OR LESS	32%	22%

EXHIBIT II-3

STUDENT MICROCOMPUTER ACTIVITIES*

	NUMBER OF MINUTES PER WEEK (MEDIAN)	
ACTIVITY	ELEMENTARY SCHOOLS	SECONDARY SCHOOLS
INTRODUCTION TO COMPUTERS, PROGRAMMING, ETC.	19	55
DRILL-AND-PRACTICE	13	17
GAMES, ENRICHMENT	12	11
TOOL APPLICATIONS	--	30

*Source: "School Uses of Microcomputers: Reports From A National Survey", Henry J. Becker, The Johns Hopkins University.

In sum, available data indicate that there are a large number of computers in the schools, that they are used for various purposes, and that they are used relatively little per week and per student. Whether the extent of use has changed in the past few years is as yet undocumented.

b. Factors Influencing Computer Use

In the late 1970s and early 1980s, the initial use of microcomputers in public schools was essentially a "grass roots" movement led by school staff -- especially science and math teachers who were computer buffs. This movement has, in recent years, been bolstered by parents who want their children to have access to computers in school.[8] Throughout the 1980s, educational use of computers has also been significantly influenced by vigorous marketing by hardware vendors and a spate of electronic education journals and conferences. Another factor influencing the growth of computers in schools has been the increased perception on the part of school staff, particularly supervisors and administrators, that the microcomputer will provide them with more control over their work environment -- better information and more rapid response times -- than they had previously using time-shared mainframe systems. Perhaps the most critical factor in the growth of computers in schools has been the rapid decline in cost of hardware in relationship to computing power (microprocessor speed and capacity) which has occurred over the last decade.

In April 1984, the National School Boards Association (NSBA), in collaboration with the National Institute of Education, conducted a survey of 1,000 randomly selected school districts on home and school computer use.[9] Although the survey's response rate was only 27 percent, severely limiting the value of the study, its findings do provide some interesting data. Responses from high-level administrators and school board members, indicated that the school district superintendent, school principals, and teachers were believed by 92 percent of the respondents to be the individuals who most encouraged the introduction of computers into their school districts. Approximately two-thirds specified that the school board strongly encouraged the use of computers, while 60 percent said parents were strong supporters and influenced the introduction of computers into the schools. Only 20 percent felt the computer industry was playing an important role in encouraging the use of computers in their schools.

During the last two years, state education agencies have increasingly encouraged the use of microcomputers in public schools. Before 1981, only seven states had state-wide policies related to education technology. Since 1982, 40 additional states have developed formal policies and initiatives in one or more of the following areas: (a) staff training -- 47 states; (b) software evaluation and dissemination -- 31 states; (c) courseware distribution -- 35 states; (d) dissemination of information -- 40 states; and (e) computer literacy guidelines or mandates -- 25 states. Examples of state-level policies that are already having significant impacts on the use of computers at the school district level are:

- state-wide telecommunication systems which will allow for electronic distribution of courseware (West Virginia, Maryland);
- state-wide adoptions and/or subsidized purchases of courseware (Minnesota, Texas, California);

* state-level policies for CMI which will countervail vendor advertising for CAI (Georgia); and

* state-mandated formats for state and local education reporting networks, which will result in greater hardware standardization (West Virginia, Tennessee).

c. Decision Making/Budgeting

Computer acquisition decisions may have a significant impact on how computers are used in schools. In those elementary schools where a group of teachers led the initial microcomputer effort, microcomputers were used for more hours of the week and had greater use by all types of students (an average of 43 percent of the students used them). Moreover, the breadth of computer applications was greater. In contrast, where principals, other administrators, or a single teacher were mainly responsible for computer implementation, typically only 15 percent of the student body used the computers during any given week.[10]

Prior to 1981, more than 60 percent of school technology purchase decisions were made or strongly influenced by individual teachers and other key school-level staff.[11] Once again, this is a reflection of the grass roots movement in motion at that time. By 1983-84, the decision-making process had changed dramatically. Microcomputer hardware purchasing is definitely centralized in the majority of cases.[12] In 1983, 55 percent of the local school districts surveyed indicated that purchasing was conducted through district-level bids and 23 percent of the districts were involved in state bid/purchase situations. From the district supervisor's viewpoint, only 18 percent of the districts indicated that individual teachers or principals controlled microcomputer purchasing. Regardless of the level of decision making, approximately 80 percent of all hardware purchased by public schools in 1982-83 was directly from computer stores and retail outlets.

On the other hand, in 56 percent of the cases individual teachers recommend software for purchase at the district level. Selection and purchase decisions for different types of education software vary. For example, in 1982-83, most administrative software, including word processing and spread sheet packages, were bought at the district level while most of the curricular courseware and some of the supplemental courseware were purchased by decision makers at the building level.

Although school districts are spending less than one percent of their per-pupil expenditures on hardware, it is not clear how much computer funding is "new money" and how much is reallocated from other functions. Schools appear to be getting outside support for software purchasing. In 1983, Federal funds (primarily Chapters I and II of the Elementary and Secondary Education Act) accounted for 24 percent of schools' software budgets, district monies for 49 percent, PTA monies for 14 percent, and other monies for 13 percent. The "other" category included fund raising, donations, and state monies. Indeed, schools are turning more to local resources, including the PTA and the local business community, for support of the software budget.

Most school districts treat computer purchases as expenses rather than as capital expenditures, a tactic which encourages piecemeal procurement. A number of districts, however, are using creative financing procedures which may be harbingers of the future; these include:

- Denver (Colorado) City Schools obtained a bank loan to purchase 1,500 Apple computers;
- Austin (Texas) Independent School District recently purchased hardware/software maintenance and support as a total package;
- Districts in Rhode Island have received a total of $4 million in State funds for technology purchases from a State-wide bond issue floated by the Public Works Authority;
- A newly created state-sponsored corporation is being proposed to the legislature as an agent for the purchase of hardware, provision of services, and the development of software for schools in Arkansas; and
- The Minnesota Department of Education subsidizes local software purchasing from "quality courseware lists".

d. Regional/State Differences

Regional differences appear to be less pronounced than differences among states. Indeed, such regional patterns are not as noteworthy as they were four years ago when the north central states, led by Minnesota, had the highest ratio of microcomputers to students. State-wide initiatives undertaken by governors or legislatures tend to diffuse these regional differences. For example, New Hampshire was ranked lowest in the nation in the number of computers per student a year ago but could, as a result of an initiative announced by the Governor in July 1984, have the highest ratio within the next year.

As noted above, state-level policies have influenced the use of microcomputers at the local level, especially in states where the state education agency has a traditionally centralized role in areas such as certification, state-wide purchasing, textbook adoption, and state-wide telecommunications. For example, the nature of computer literacy courses in Utah is strongly influenced by the state-mandated law requiring all teachers to be certified as computer literate before they can be employed by a local district. The recent state-wide, total-package procurement award to Apple Computer for hardware/software training and support will greatly influence the nature of teacher training and curricula in Tennessee. The state-wide implementation of the IBM PC distributive network in West Virginia and state-wide licensing of software has already had a significant impact on school districts in that State.

e. Socioeconomic Differences

In the last four years the gap between poor and wealthy school districts (as measured by per-pupil expenditures for instructional materials and equipment, revenue raising capacity, and other indicators) has been decreasing.[13, 14] It is not clear, however, to what extent or, indeed, whether there are differences between wealthier and poorer districts with regard to the presence of computers. While some researchers report that wealthier districts are four times more likely to have microcomputers than poorer districts,[15] a Colorado study found that disadvantaged students in schools which received money under Chapter I of the Elementary and Secondary Education Act (ESEA) had more access to microcomputers than did students in non-Chapter I schools.[16] It is likely that equity issues vary among states and even among districts within states. Although virtually every state with established policies on technology use has considered the equity issue, only a handful have implemented policy which even tangentially addresses equity issues; these include: (a) California, which requires microcomputers purchased under the "Apple Bill tax credit" to be distributed to all schools; and (b) Georgia, which is formulating a state aid program which takes into account district wealth.

f. Urban/Rural Differences

Some of the best documented differences in the use of computers in education are those among urban, suburban, and rural districts. The use of technology in rural districts has been a target of much research and field experimentation, primarily in areas only peripherally related to computers (i.e., telecommunications). The National Institute of Education (NIE) has been active in this area, having sponsored a large experiment involving satellite broadcasts of instructional television and computer-assisted instruction in Appalachia and Alaska. More recently, NIE commissioned a series of case studies of computer use in rural districts. These qualitative studies, along with some survey data gathered by groups such as Market Data Retrieval, indicate several unique factors associated with current use, diffusion, and decision-making processes in rural school systems.

While parental pressure has taken over from the teacher "computer buff" as a major factor influencing the use of microcomputers in urban schools, the prime movers in smaller rural districts have continued to be computer-buff teachers and administrators. The costs per pupil in rural districts are usually higher because fewer children are served; hence, technology is often more cost-effective than in larger districts. On the other hand, because of higher per-pupil costs, the availability of any funds to purchase the technology, even when it is relatively cost-effective in providing a service, often does not exist.

In many rural districts, technology is perceived to be a means of filling certain voids. Many rural districts cannot support quality programs in some areas because of the lack of specialized teachers or high teacher turnover rates.[17] After staff salaries, the largest budget item in most rural school systems is transportation, an area in which telecommunications (incorporating microcomputers) offers a serious cost-effective alternative (e.g., home-bound CAI, in-service training). Moreover, rural districts often perceive technology, not as a replacement of staff, but as a means to provide a service not available through any other means.

A major factor affecting the use of microcomputers in rural districts is the degree to which certain technologies prove successful in providing substitute or improved service in states with geographically dispersed population centers. Computer and audio teleconferencing for in-service teacher training has been effective and is now commonplace in Alaska.[18] Electronic mail/bulletin boards, operated state-wide in Kansas and Montana, have demonstrated their value in disseminating information about software evaluations, exemplary teaching practices, and other topics to rural districts in these states.[19] In small rural districts, the availability of in-place telecommunication networks has contributed to high ratios of microcomputers to students.

Political factors also play a part in computer adoption in rural areas. Officials in rural districts often perceive technology as a means to resist school district consolidation attempts by state education agencies. Such consolidation pressures are often based on the desire to provide a full range of education services to all students. If rural school systems can demonstrate that computers and telecommunications are effective in providing certain services, they will be better prepared to maintain the political and social integrity of the school system within their community. In rural school districts, the opportunities for decision making using cost trade-offs are usually greater than in urban districts. Generally speaking, rural districts are less formal and bureaucratic and are less likely to face rigid teacher union bargaining agreements than are urban and suburban school systems.

One of the problems confronting rural computer users is the lack of readily available maintenance, support, and service. Increased reliability of hardware and user-friendliness of software have contributed to the use of microcomputers more in rural than in urban communities. Interestingly, many rural districts have developed their own in-house maintenance and repair groups, which often include junior and senior high students.

Urban school systems often face technology-related issues which are vastly different from those of rural schools. A survey of approximately 50 core city school systems (including such diverse major urban centers as San Francisco, Dallas, Rochester) identified several of these urban issues.[20]

- Instructional use of computers in urban schools focuses primarily on courses that use the computer as the object of instruction. Fifty percent of the districts surveyed had at least one introductory computer course, usually in the 7th through 12th grade; most of the remaining districts reported they did not have a formal computer course, but rather that "literacy" (knowledge about computers) was infused throughout the curriculum as part of the computer-assisted instruction plan. All districts had secondary-level computer science courses, with the average district having seven such offerings.

- The number, scope, and variety of administrative applications in urban districts is much greater than in rural districts. In addition to providing their own finance, personnel, student record keeping, scheduling, testing, research, and payroll functions, many districts have begun to computerize library books, transportation routes, food services, curriculum information, and energy use patterns. At the building level, moreover, as a result of the microcomputer, an increase in the number of administrative applications has occurred as microcomputers now manage course loads, handle attendance, provide vocational guidance information, arrange schedules, manage grade reports, develop IEPs for special education students, etc. Moreover, approximately 40 percent of districts with microcomputers are currently using some form of electronic mail; this is projected to increase to 70 percent within the next year. Many of these electronic mail systems involve school building to district office networks.

- Approximately one-half of the urban districts surveyed have a district-wide plan for computer use which has been approved in the last three years. Forty percent were in the process of developing such a plan. Unlike rural districts in which most plans continue to be developed by individuals, most urban districts' plans are developed by committees comprised of administrators, teachers, parents, and consultants. While individual computer-buff teachers were, in the past, instrumental in initial introduction of microcomputers in urban districts, the evolution of broad-based committees have more recently had a significant influence on school decisions.

- An important factor in the current use of microcomputers in urban districts relates to the bureaucratic structures of these districts and the prior existence of a computer-based infrastructure. Whereas all educational technology historically had been handled by the school divisions dealing with finance or data processing, more than 60 percent of the districts had one office primarily related to computers used in data processing, finance, payroll, and personnel <u>and</u> a newly created office with primary responsibility for instructional technology purchasing, in-service training, etc. Only 21 percent of the districts still had just one division responsible for computer use, while approximately 17 percent had three or more such divisions. In approximately 70 percent of districts, the type and brand of hardware and courseware to be purchased is managed at the central office; in 30 percent of the districts, individual school principals make most purchasing decisions. Only 20 percent of the districts require central office approval for specific brands of courseware. This represents a significant loss of authority for many entrenched data processing bureaucracies and is the source of considerable political infighting within these districts. The existence or lack of clearly delineated decision-making roles and responsibilities in urban districts has had an impact on the nature and extent of computer use in schools.

2. SPECIAL EDUCATION

For purposes of this report, the term "special education" means specialized instruction given to students who are in some way handicapped or exceptional (e.g., learning disabled, educable mentally retarded, gifted and talented).

The use of computers has been greater in special education than in the other "thin" educational markets (e.g., bilingual education, vocational education). One estimate[21] of the number of microcomputers used in special education during the 1982-83 school year was approximately 25,000, of which 10,000 were used primarily for administrative purposes and 15,000 for instruction. It was projected that 150,000 microcomputers would be used in special education by 1985-86, with approximately 85 percent used primarily for instruction and 15 percent for administration.[22] Recent estimates indicate that, by the end of 1984, almost 150,000 microcomputers were being used in special education and gifted-and-talented programs for a combination of instructional and administrative functions.[23, 24]

A 1982 survey indicated that approximately 80 percent of all computer administrative applications in special education were of a single-purpose nature.[25] Ninety-four percent of the districts surveyed used such single-purpose packages for student attendance and enrollment, while 45 percent used them for student tracking; only 12 percent used them for assessment. Less than 20 percent of the packages were comprehensive (e.g., multipurpose); yet 80 percent of the respondents indicated a need for such multipurpose, comprehensive packages. In a later study, 45 percent of the respondents stated their district plans called for an increased use of microcomputer technology in both special education administration and instruction, with a large majority recognizing the need for multipurpose administrative packages.[26]

Instructional applications for special education students have been limited, until recently, by the lack of commercially available courseware. Approximately 60 percent of courseware used in special education is primarily drill-and-practice. However, special educators have expressed a strong need for simulations and tutorial type programs for introducing concepts. High demand subject areas include reading and language arts, computer literacy, and survival skills. In these areas, only about 15 percent of general education courseware could be used with special education populations.[27] Within the last year, however, a number of publishers have announced new courseware products which are modifiable or adjustable by special education teachers for use with specific populations. For example, in approximately 100 new courseware titles, teachers can adjust response times, change word lists, etc. to suit slower learners. Recent research findings indicate that adjustable courseware is critical for certain special education populations.[28]

Several factors have contributed to the rapid increase in the instructional and administrative use of microcomputers in special education:

1. In 1975, passage of The Education for All Handicapped Children Act (P.L. 94-142) required: (a) the development of individualized education programs (IEPs) for each special education student; (b) detailed student processing and procedural safeguards to which each special education student is entitled; and (c) increased reporting requirements at both the local and state levels. As a result of the procedural safeguards and administrative processing requirements mandated by law, the microcomputer was perceived to be an important administrative tool which could reduce staff time and paper work. Indeed, recent evaluations of the use of administrative and IEP development packages indicate that, in several sites, staff time in developing and updating IEPs has been reduced by a factor of ten.[29, 30] By requiring an IEP for every child, the law also generates a demand for instructional management applications to monitor individual student progress at various levels.

2. Once considered a thin market, special education has received increasing attention from private courseware developers, electronic publishers, equipment vendors, and others. There has been a significant increase in Federal, state, and local expenditures in special education in

recent years -- from approximately $4.6 billion in 1976 to an estimated $12 billion in 1983, to a projected $15 billion in 1985.[31] One estimate suggests that expenditures for special education instructional equipment and materials will jump from $360 million in 1982 to $650 million in 1985.[32]

3. There has been growing recognition of the high costs of providing services to handicapped students. The costs of administrative processing and overhead for handicapped students are approximately $500 per year compared to $200 per year for a nonhandicapped student. These figures do not include an additional $200 to $300 per pupil for IEP development and assessment.[33] To meet the demand for reducing these costs, there are approximately 80 commercially available administrative/IEP development packages presently available on microcomputers for use in special education.

4. There has been increasing pressure from parents who are becoming more aware of the availability of adaptive devices for handicapped students. In some instances, parents and civil rights lawyers have pressured schools to purchase adaptive devices which would allow sight or hearing impaired students to have equal access to computer-assisted instruction. The cost of many such adaptive devices has dropped dramatically in the last three or four years.

5. The U. S. Department of Education has implemented a strategy specifically focusing upon technology use in special education. The Office of Special Education Programs strategy consists of several components: (a) funding of several million dollars of projects designed to adapt regular education courseware to meet the needs of special education populations; (b) a large-scale technical assistance effort to assist state and local education agencies in planning for the use of technology; (c) establishment of several information clearinghouses and data bases on special education software evaluation and related issues; and (d) its Market Linkage Project which is designed to facilitate effective communications between developers and marketing and distribution groups to subsidize some of the costs of publishers and distributors.

3. VOCATIONAL EDUCATION

Unlike existing data bases on microcomputers in special education, there is virtually no nationwide information on the current use of microcomputers in vocational education. The best available data are from a survey of schools in six north central states. Before reviewing the findings, two caveats are in order. These states generally have higher student participation rates in vocational education than other regions of the country and they have traditionally been the most active in computer use in education.[34] Therefore, it follows that this region of the country may well have a higher degree of computer use in vocational education than other areas of the country.

It is clear from the survey that more microcomputers are interfaced with mainframes in vocational education than in general education. In addition, approximately 25 percent of the respondents indicated they were using local area networks of computers, with another 25 percent actively considering such networks. In most instances, the local area network being used was at the classroom or building level, rather than throughout the school district or in combination with intermediate units.

In the administration of vocational education, the greatest use was in the area of word processing (57 percent of responses); data base applications and finance/accounting were about equal (46 percent); followed by analyses and spread sheets (41 percent). Electronic mail use was reported in about ten percent of the responses.

In the instructional area, 72 percent of the respondents indicated that microcomputers were being used for teaching word processing, followed by computer-assisted instruction (66 percent); data base management (52 percent); educational simulations (53 percent); test generation (44 percent); and computer-managed instruction (33 percent). The extensive use of microcomputers to generate and score tests was much higher than in general education or special education, reflecting the general use of competency-based education and testing in vocational education. CMI applications and educational simulations were also used more in vocational education than in general education as are educational simulations.

Microcomputers were also used in counseling, placement, and support areas. They were used as part of occupational information systems in approximately 54 percent of the sites, while a lesser number (33 percent) used them in counseling, and a still smaller percentage for job placement (23 percent).

In terms of vocational groups, the survey found that microcomputers were used most intensively in business education; the leading business education categories included data processing, word processing, accounting, and bookkeeping. Industrial/technical education constituted the second highest applications group; applications of high use included electronics, computer graphics, computer technology, and robotics. Following this group was agricultural education, in which farm management and accounting was cited as the highest application, followed by financial projections and crop management. Other occupational areas with some degree of instructional computer use included home economics, distributive education, and health occupations, in that order.

Within the size and geographic limitations of this survey, some generalizations can be made. Although computer use in these states is generally not representative of the nation as a whole, it can be used to formulate an upper-bound estimate of the number of computers in vocational education. Such an estimate would indicate that approximately 80,000 microcomputers were being used for vocational education in public schools and in vocational tech centers during the 1983-84 school year.

Current studies indicate that the increase in computer use in vocational education will be lower than that in education generally. An important software consideration which will have an impact on future computer use in vocational education is the ease with which courseware developed for industrial or military training can be "transferred" to vocational education program settings. From survey results, it is clear that a large number of vocational education programs are using instructional packages originally designed for use in industry.

Another factor which affects the use of microcomputers in vocational education is the degree to which industry and school districts work as partners in the education and training process. Vocational education is closely related to the use of technology in industry. The degree to which schools are responsive to providing the job skills demanded by industry and the degree to which industry assists schools in this process has a direct impact upon the use of computers and electronic learning technology in vocational education.

4. BILINGUAL EDUCATION

Relatively little is known about the current use of computers in education programs for students with limited English proficiency (LEP). A recent study[35] identified some trends in basic and demonstration programs funded by the U. S. Department of Education. This study found a significant increase in the use of computers in the 115 bilingual education projects funded by the Department between 1983 and 1984. In 1983, only three projects involved computers; in 1984, approximately 60 were computer-related. Of those 60 projects, approximately 50 used the computer primarily for instructional purposes, with a secondary emphasis on the use of the computer as the object of instruction (i.e., "computer literacy"). In four of the projects, the primary purpose was the computer as the object of instruction with the remainder of the projects focusing on record keeping, test scoring, and other simple applications.

Findings from a survey of computer use patterns in Texas schools (which, because of their large Hispanic populations, might reasonably be expected to have higher than average involvement in bilingual education) clearly indicate that English as a second language (ESL) represented the lowest computer-use category. At the elementary level, 50 percent of the schools used computers in gifted, general, and remedial education. Its use in ESL was found only in about 15 percent of the respondents. At the junior high level, computer use in ESL was less than ten percent, and even lower at the senior high level.[36]

The principal bottleneck in the use of computers for LEP students appears to be courseware. A study of courseware available in 1982-83 reported that more than 500 courseware titles were available for 14 different languages, approximately 30 percent for ESL, led by French, Spanish, and German in that order.[37] Approximately 50 percent of the courseware could be classified as drill-and-practice, and about 35 percent was designed for intermediate-level students focusing primarily upon grammar. Less than ten percent of the courseware had been evaluated or reviewed in some systematic manner -- much less than in general education. Currently, teachers of LEP students reject approximately 80 percent of the available courseware -- for a variety of reasons -- as not effective for LEP students.

Moreover, privately-funded development and distribution of courseware projects has been relatively small because of the limited nature of the market and the large number of market segments (i.e., different languages). Over time, increased courseware availability for Spanish LEP students can be expected; however, for some very thin market segments, courseware will probably only be developed through Federally-funded materials development centers and by individual teachers or school districts. One of the largest bilingual courseware development projects in the country is being funded primarily through local funds in the Houston (Texas) Independent School District.

During a recent conference on technology in bilingual education[38], prominent researchers identified types of courseware which are needed for instructing LEP students:

1. The courseware must be language-intensive; most courseware is for English as a second language and for foreign language training and is primarily in Spanish and French.

2. The courseware must allow for individualized pacing and student control.

3. If the courseware is of a drill-and-practice nature, it must be very clear to teachers how the courseware can be integrated into existing curricula. Tutorial and simulation programs must take into account the differing cultures from which LEP students come.

4. The courseware must have been vigorously field-tested and evaluated.

Introductory computer courses for LEP students are, for the most part, provided at the junior high and senior high levels. While some schools teach computer programming, most minimize the need for computer programming and focus upon orientation, awareness, and application. Most computer introduction and CAI applications occur in the areas of math and science; many LEP students, when tested, do not have the necessary scores to qualify for these course offerings.

The availability and accessibility of hardware is another factor constraining computer use in LEP programs. The availability of microcomputers in school districts with large Hispanic populations is considerably lower than in schools generally.[39] Moreover, the different alphabets of some languages severely limit the use of computers in language education. Specialized printing fonts and operating systems are necessary for operation with such languages. Advances in interfaces between microcomputers and videodiscs also offer unique opportunities for expanding the use of intelligent videodiscs in programs for LEP students by providing improved pictorial representations so important in foreign language instruction.

Another important factor is teacher training. At present, only one institute for higher education (i.e., San Diego State University) has initiated a formal pre-service training program on technology use in bilingual education. (By contrast, teacher training institutions in 20 states have such programs for general education.[40]) The directors of this program believe that any pre- or in-service training program for bilingual teachers must, like general education, include components which will assist teachers in: (a) developing and integrating courseware into curriculum; (b) developing good tests; (c) evaluating software and courseware; and (d) using the computer in both CMI and CAI modes.

B. PROJECTED COMPUTER USE

In this section we present information on the projected educational use of computers during the next decade, with particular emphasis on the period from 1985 to 1990, which might be considered a scenario for computer use during the next five school years.

1. HARDWARE

Estimates of the number of stand-alone microcomputers in America's schools have been made by a number of organizations. The most reliable of the recent estimates have been made by market research firms specializing in education.

In the 1980-81 school year only about 30,000 microcomputers were in the schools (along with about 20,000 terminals connected to larger computers).[41] Since then, while microcomputers have proliferated, little change has occurred in the number of larger computers in schools. Exhibit II-4 charts the rise of microcomputers in the schools.

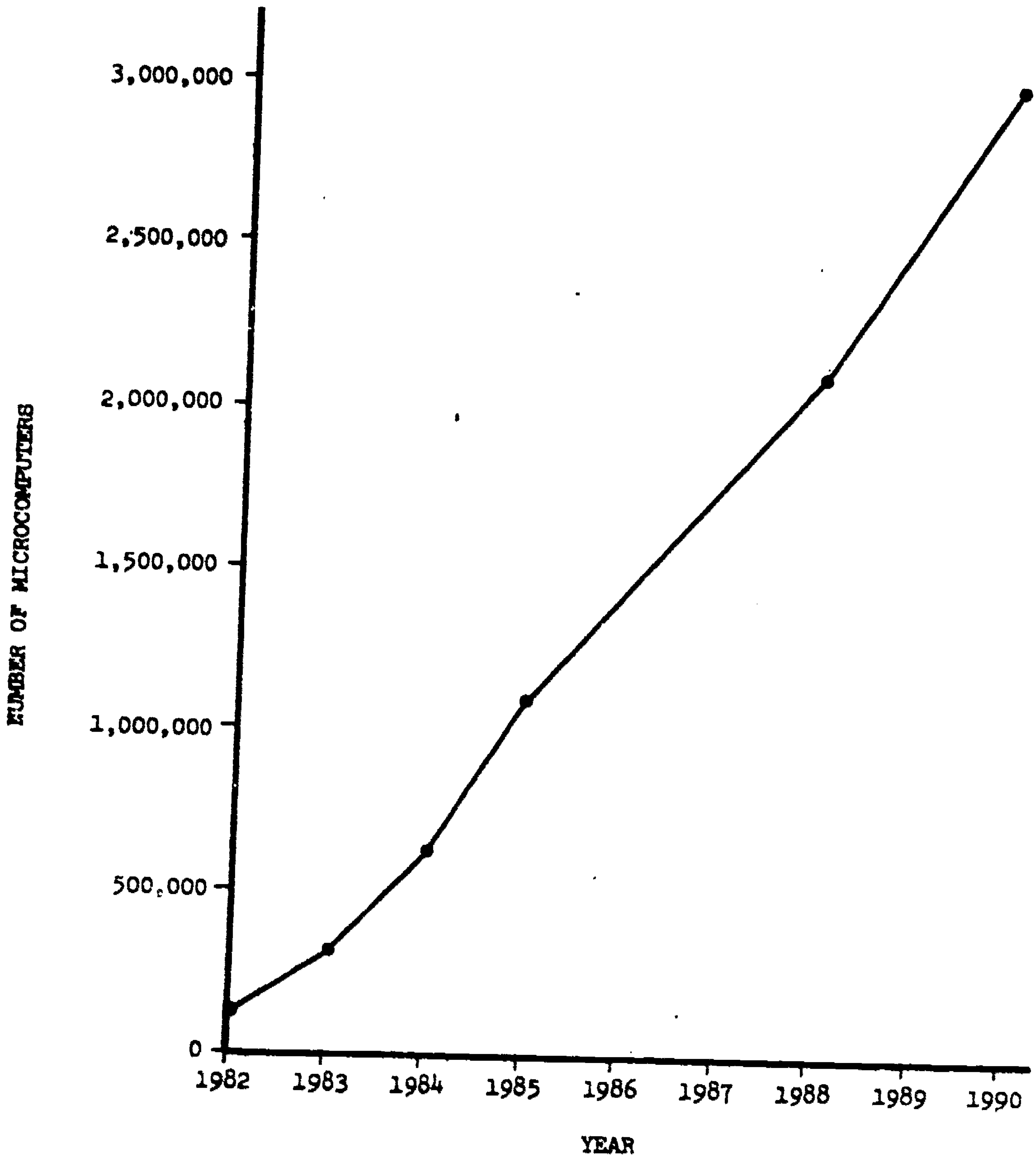
In a period of two to three years, the number of microcomputers rose from 30,000 to approximately 300,000.[42] Within about one more year, the total inventory of school-based microcomputers doubled to more than 600,000 in 1984. Recent projections indicate that, by June 1985, the number of microcomputers will nearly double again to about 1.1 million and by June 1988 the inventory will reach 2.1 million.[43] Although these projections are only a few months old, some evidence exists that they understate the future inventory of computers in schools. By 1990, the number of microcomputers in public schools is projected at between 2.8 and 3 million units.[44]

Most experts agree that by 1988 the typical elementary school will have approximately 25 microcomputers; a typical high school will have approximately 30. There will be about 25 students for every microcomputer. By the end of 1985, the total public school investment in computer hardware (between 1980 and 1985) will be approximately $25 per student, significantly less than one percent of the current average annual per-pupil expenditure.

There exist other technologies which hold the potential to enhance the value of microcomputers. Foremost among these is interactive video. Most experts agree that prerecorded personal computer software will begin to be replaced (or augmented) by interactive video during the late 1980s and early 1990s. A number of factors will cause this change, including: (a) increasingly user-friendly personal computer hardware and software; (b) ease of incorporation of computers into television sets and other component systems; (c) increased availability of interactive personal computer software; and (d) lower prices. However, a major breakthrough will be the emergence of the erasable videodisc to store error-free logical and numerical data. Such erasable videodiscs may enter the commercial market any time between 1986 and 1988. When videodiscs have the capability of storing both logical and video data and prices become sufficiently low, by 1990 videodiscs could replace floppy discs for many microcomputer applications and greatly enhance the quality of educational software.

NUMBER OF MICROCOMPUTERS IN U.S. SCHOOLS

(AVERAGE OF RESEARCH ESTIMATES)



2. SOFTWARE

Total annual software sales to schools were about $22 million by June 1982. They are projected to be at least $300 million by 1987.[45] Most experts believe that, before the end of the decade, annual school software sales will surpass annual hardware sales to schools.

The amount of commercial software used on the typical microcomputer in schools is three to four packages valued at approximately $150 each. While the number of courseware packages available for each microcomputer will increase by 1990, the unit price should decrease as the result of increased competition, greater efficiency in production, and increased use of networking/ telecommunications in the public schools.

Between 50 and 70 percent of the price of a typical courseware package can be attributed directly to marketing and distribution costs. In 1982, about 40 percent of the courseware purchased by public schools came from retail outlets; only 13 percent was purchased directly from traditional education dealers. The remainder of sales were made from catalogues, direct mail, etc. In 1984, according to a number of reports, high costs of courseware marketing and distribution were considered a major obstacle to expanded use of microcomputers in both the home and education markets.[46]

As an alternative to existing patterns of software distribution, distribution by electronic means has, or will shortly, become feasible:

- The concept of the local education utility has been developed by the National Information Utilities Corporation (NIU). In this model, as courseware is entered into a central system, it is transmitted through an uplink to a satellite which, in turn, sends it to a local transmitter. The courseware is then broadcast directly to host computers in a district school. The digitized data can be transmitted 30 times faster than traditional distributive networks using telephone lines and modems. Students in the classroom share microcomputers or terminals which allow them to access courseware under teacher control. The school pays user fees based on the type and amount of courseware used. The potential advantages of this type of system are several fold. First, it can greatly reduce the cost of courseware distribution when compared to traditional means. Second, it encourages developers/publishers to develop quality courseware because royalties will be determined by use rates and software piracy minimized. Third, it encourages school staff to use the computer software in an appropriate and effective manner in those areas where CAI, for example, appears to be more cost-effective and appropriate than traditional methods. Fourth, this utility concept provides opportunities to use under-utilized technology infrastructures, such as education television networks, which encourages state-level involvement.

- Existing telecommunications systems can also be used for courseware distribution. Networks such as THE SOURCE and CompuServe can transmit courseware to schools; however, these systems are still dependent upon telephone lines and have relatively high costs. Commodore International, Bell South, and Control Video Corporation, however, are field-testing a variation of this distribution concept primarily for home computer courseware review and distribution. This system relies heavily on local telephone lines but provides for a relatively low-cost master modem as the telecommunications interface, thus reducing connect time charges.

- Through the use of videotex, courseware could be transmitted to schools through television signals. Such a system is being considered on a state-wide basis in Delaware as an alternative to the existing educational network of time-shared, computer-based curriculum which now serves several thousand students in the State.

While each of these alternative systems has its advantages and disadvantages, it is clear that electronic distribution of software will have a dramatic impact on educational computer use. It should lower the price of courseware, facilitate software updating, and encourage heavier investments by publishers and developers in the development of quality software. If current trends continue, most experts agree that by 1990 more than one-half of educational courseware will be distributed to schools by electronic means.

3. MANAGEMENT OF TECHNOLOGY

Future computer use in schools depends on the degree to which school decision makers take the necessary initiatives to use technological advances effectively. Virtually all experts agree that the initiatives with the greatest potential impact are:

- Proactive Planning versus Reactive Behavior: Less than 20 percent of the public schools in this country have plans for the effective use of computers and related technology in education. Without such planning, effective use will be minimal, with school decision making focusing upon crises and external pressures. Only one large urban district (Houston, see below) has established a 20-year plan which takes into account probable technology advances in the next two decades and is attempting to plan for the effective integration of technology into areas ranging from facilities to course offerings.

- Staff Training: The nature and extent of staff computer-related training has changed considerably in the last four to five years. Initially focusing on how to operate computers, a growing number of school districts and some teacher colleges are beginning to address such areas as applications, courseware selection, and integration into curricula. In the next two years, some multilevel, sequenced packages of integrated software and basal textbook series will be used in the area of math and reading, particularly at the K-8 level. Some of this courseware will incorporate concepts, such as expert systems, from the field of artificial intelligence which can be used to assist teachers in managing elements of the instructional process (e.g., diagnosis/prescription). However, the widespread use of such integrated courseware and computer-managed instructional systems will require massive teacher training/retraining efforts focusing upon individualized instruction. Such investments in staff development will be much more costly and time-consuming than existing teacher training in the use of the current generation of courseware.

- Centralized versus Decentralized Control: One of the major factors contributing to the initial growth of microcomputers in schools was the perceived opportunity for increased control on the part of the administrator or teacher. Several anticipated advances in technology will result from the convergence of telecommunications and microcomputers. This convergence implies higher degrees of centralization, whether at the state level, through the distribution of courseware via electronic means, or at the school building level, through the use of local area networks. Often state or district objectives of greater efficiency through economies of scale offered by telecommunications will run counter to many control and flexibility concerns of building level staff, including teachers. The degree to which the technology can offer opportunities for multilevel decision making and control will contribute significantly to the degree to which schools will take advantage of these telecommunication/microcomputer marriages.

- Institutional Reform versus Technology Interventions: Over the last five years, most computer applications have focused on specific populations and have been used for enrichment purposes. Only a small number of innovative state and local school officials perceive the need for total institutional reform of the public schools. Indeed, if the potential benefits of computer use in the schools are to be realized, existing institutional barriers must be removed. For example, incentives must be provided to ensure that computer technology can improve staff productivity and student performance. Flexible student scheduling will be required if individualized student-directed instruction and computer-managed instruction achieve their objectives. Staff certification must be performance-based if staff training needs are to be met effectively.

4. OTHER CONTRIBUTING FACTORS

There are a number of important factors that will influence the nature and extent of computer use in America's schools during the next few years.

a. Use with Targeted Groups

Most experts agree that, in the next two years, a large number of useful software packages will be commercially available to satisfy many, but not all, of the needs of special education students and staff. An increasing number of publishers and developers can be expected to announce adjustable courseware packages which can be used with handicapped learners, many in conjunction with adaptive devices and communication aids.

Over the next two years, the number of multipurpose special education administrative applications which allow for user customization through templates and authoring techniques to meet local and state needs will increase. Many of these packages will allow for telecommunication with state education agencies, especially in states where state and local education networks are being planned. Approximately 35 states are planning and/or implementing such state-wide networks for reporting purposes in special education. Most experts agree that within the next five years, software applications will become available which rely upon expert systems technology (from the field of artificial intelligence) to assist special education teachers to diagnose learning difficulties and prescribe appropriate learning strategies.

Unlike special education, where handicapped learners are prevalent in the population in virtually every school district, LEP students are disproportionately dispersed throughout the country. A factor which will affect the incidence of computers in bilingual education will be the speed and manner in which programs for LEP students are fully integrated into local school systems planning, budgeting, and decision-making cycles. For the most part, ESL and LEP programs are seen by local district officials as Federal or state categorical programs. Indeed, most of the computer initiatives in these programs have been supported through discretionary funding from the U. S. Department of Education or from special set-aside funding from states with large percentages of LEP students. As with other special populations, the Federal government has assumed some responsibility for ensuring the availability of programs and materials and has provided assistance and information dissemination (e.g., the National Clearinghouse for Bilingual Education). If microcomputers are to be used in an effective manner in bilingual education, however, school district officials will have to plan for the systematic integration of LEP programs into their regular curriculum. Most experts agree that unless Federal funds are targeted for CAI development, the use of CAI in LEP or bilingual programs will continue to be substantially lower than in other thin educational markets.

In the next five years, vocational education programs are likely to be more dependent than other program areas on software developed for industry or military training purposes. Critical will be the extent to which industry and school districts work as partners in the education and training process. The degree to which schools are responsive to providing the job skills demanded by industry and the degree to which industry assists schools in this process will have a direct impact upon the use of computers and electronic learning technology in vocational education.

b. Curriculum Integration

One important factor which will affect future computer use in schools is the extent to which courseware is integrated into school curricula. A June 1984 survey found that computers had not changed the methods or content of instruction in 80 percent of the school districts which responded.[47] Of those districts reporting that computer usage had altered methods or the content of instruction, mathematics, business education, English, and the sciences (in that order) were the most affected. Eighty-six percent of responding districts had no school board policy or guidelines in the selection of courseware or software, and 68 percent had no policy on the selection of textbooks that applied to computer courseware or software. In the approximately 20 states which have state-mandated curricula and quality standards, most have undertaken some formal or informal initiatives to ensure that existing supplemental courseware is capable of being integrated into their curricula. For example, Texas and California are seriously considering requiring demonstrations of available courseware, which can be integrated into basal text, as a part of the state-wide textbook adoption process. States interested in attracting "high tech" industry are investing educational dollars in the establishment of computer curricula.

At the operational level, most educators perceive an important need for microcomputer integration into school curricula. According to a recent survey, teachers want new courseware to be closely tied to curriculum content and feel a variety of print materials should accompany the software. "Teachers want complete packages, not just a disc. They want a teacher's manual, a student handbook, activity sheets, and other related materials for classroom reading.[48]

Contributing to the problem is the lack of commercially available courseware which can be easily integrated into curricula or which is packaged as part of curricula. Most electronic learning publishers are distributing low-price supplemental courseware for large volume markets (e.g., students) rather than CMI packages which could facilitate integration for smaller markets (e.g., teachers). Some have attempted to repackage (with a teacher's manual) education courseware designed for the home market and sell these supplemental non-curriculum (for the most part, drill-and-practice or simulation) programs to the schools at higher prices.

Several factors which are likely to facilitate courseware integration into curricula include:

- requirements for integrated courseware/basal series in several major states which have state-wide textbook adoptions (such as California and Texas), that could have a significant impact on the nature of courseware developed and marketed by publishers;
- increased promotion by states of computer-managed instruction at the local level, which in turn could affect commercially available products and the opportunities for integration at the local district level;
- the inclusion of software selection, courseware curriculum integration, and individualized instruction as major components in pre-service and in-service teacher training programs; and
- continued development of policies and guidelines for ensuring effective integration of courseware into curriculum.

All of these events can be expected to occur in some school districts within the three to five years, having a major impact upon both schools and publishers. By 1990, however, there will be a small cadre of about 500 computer-using school districts in which courseware will be integrated effectively into the curriculum. Such schools will help provide leadership to other schools.

c. <u>Home and Community Pressures</u>

Expanded use of computers in schools during the remainder of this decade will be greatly influenced by parents, parent groups, and the local community.

Educational computer use in the home -- as measured by software purchases -- is projected to increase dramatically, from approximately $7 million in 1981 to about $1 billion projected by 1989.[49] Home use of computers will continue throughout the decade to bring pressures toward expanded use of computers in the public schools. If the growth in home computer use continues, there will be significant but uncertain effects upon public and private education. On one hand, the availability of microcomputers in the home provides opportunities for schools to build better relations with parents through improved coordination of such activities as homework and courseware selection. On the other hand, frustrated parents with computers are increasingly likely to take their children out of public schools and educate them in private schools or at home.

5. ONE SCENARIO FOR THE FUTURE

No market research firm has made any serious projections related to the use of computers in education through 1995. However, one large urban school district, the Houston (Texas) Independent School District (HISD), one of the leading computer-using districts in the nation, has made such projections as the basis of its 20-year technology plan. Many of the projections summarized below are based upon that plan.[50]

By the end of the decade, HISD is projecting a decline in the ratio of students per microcomputer from its current level of approximately 50:1 to about 15:1. Approximately 250 local area networks (one per school) will have been installed and connected to an average of 40 microcomputers per network. The local area networks will increasingly be used for student access to data bases stored on relatively low cost compact discs which will store several hundred million bytes of information. Inexpensive local optical storage will replace high-cost telephone telecommunication access to existing large data bases such as Dialog, BRS, CompuServe, etc. In addition, they project that by 1990, more than 300 interactive videodisc units will be in place within HISD. The videodisc will become a major enhancement for the microcomputers, providing even more powerful education capabilities.

By 1993, HISD projects 30,000 microcomputers in service, with two-thirds being full-screen portable notebook microcomputers. In addition, they anticipate that approximately 50,000 portable notebook computers will have been purchased individually by students or, for equity reasons, purchased by the district for use by individual students. Hence, within each school, a capability will exist for a computer connection, most likely through two-way cable networks, for each student. They also anticipate a need for significant growth in peripheral equipment, such as fast, inexpensive laser printers, large screen displays to facilitate group learning experiences, and voice input systems.

By 1995, they anticipate extensive microcomputer use in administration and instructional management. Administrators will use computers for education planning and budgeting, scheduling, inventory control, and related administrative applications. Instructional management systems will allow the computer to reduce teachers' routinized activities and clerical chores (e.g., attendance, record keeping) and to provide opportunities for sophisticated instructional decision making. By this time, the impact of artificial intelligence and expert systems will have been transferred to education and will be commercially available, at relatively low costs, for use by school decision makers. Or it may be integrated into curriculum management systems and diagnostic/prescriptive functions associated with the learning process.

To the extent the HISD projections are generalizable to schools nationally, several trends become clear.

- Sophisticated computer-management systems will become widely used in education because:
  - they will be strongly encouraged (or mandated) by state-level policies and adoption procedures;
  - massive teacher retraining efforts in the use of individualized instruction and instructional management will have occurred during the late 1980s;
  - expert systems technology will have been transferred from military and industrial training and decision making into education; and
  - electronic learning publishers will finally make a serious investment in courseware development, building upon advancing technology to meet the needs of the schools.
- The microcomputer, as we know it today, will change dramatically as it converges with other technologies (e.g., telecommunications, videodiscs).
- Other existing configurations will also change; for example, the local area computer network of today may become a more comprehensive, flexible, and lower cost network. The local school district may become the hub of an information utility to which students who own their own computer notebooks can connect while they are both in the school environment and at home.
- The nature and extent of computer use will be largely driven by the availability of quality software, which will increasingly include simulations, tutorials, discovery, and other modes of interaction heretofore yet to surface.

III. PERFORMANCE EFFECTS

This chapter explores the effects of computers on students, including their academic performance and attitudes. It first presents background information on current school practices. This is followed by a review of the literature concerning the effects and effectiveness of computer-assisted instruction (CAI) and computer-managed instruction (CMI). The chapter ends with projections of the effects which computer use in school may have on students.

The information in this chapter has been gathered from research conducted during the past 16 years. The project has relied most heavily on 15 studies focusing upon effectiveness of CAI. It should be noted that most of these studies concentrated primarily upon the use of mainframe or minicomputer programs. The extent to which these findings can be generalized to experiences with microcomputers is uncertain. For several reasons, there may be differences in performance effects between the larger mainframe/minicomputer systems and the smaller stand-alone or networked microcomputers. Teachers and students may experience a greater sense of control over their learning environments when using stand-alone computers because there is less potential for interference from outside elements (e.g., operators in a mainframe system). Moreover, there are many technical problems associated with interconnected systems (e.g., operating system "down time", interruptions in communications) which can effect system operation. For these reasons, the effects associated with the use of stand-alone or network microcomputers have been isolated.

The effects of computers on student performance and attitudes are surrounded by a number of complex issues which further complicate the study of these effects. Research and development efforts conducted during the past few years have shown that the effects of computer-based instruction on students are related to teachers' attitudes toward technology, the quality of educational software, and the implementation variables associated with adopting CAI and CMI in schools. In addition, the growing educational use of home computers appears to be having an impact upon computer use in schools. This chapter presents the relatively sparse research findings in the areas mentioned above, in addition to student effects, with the provisos discussed above.

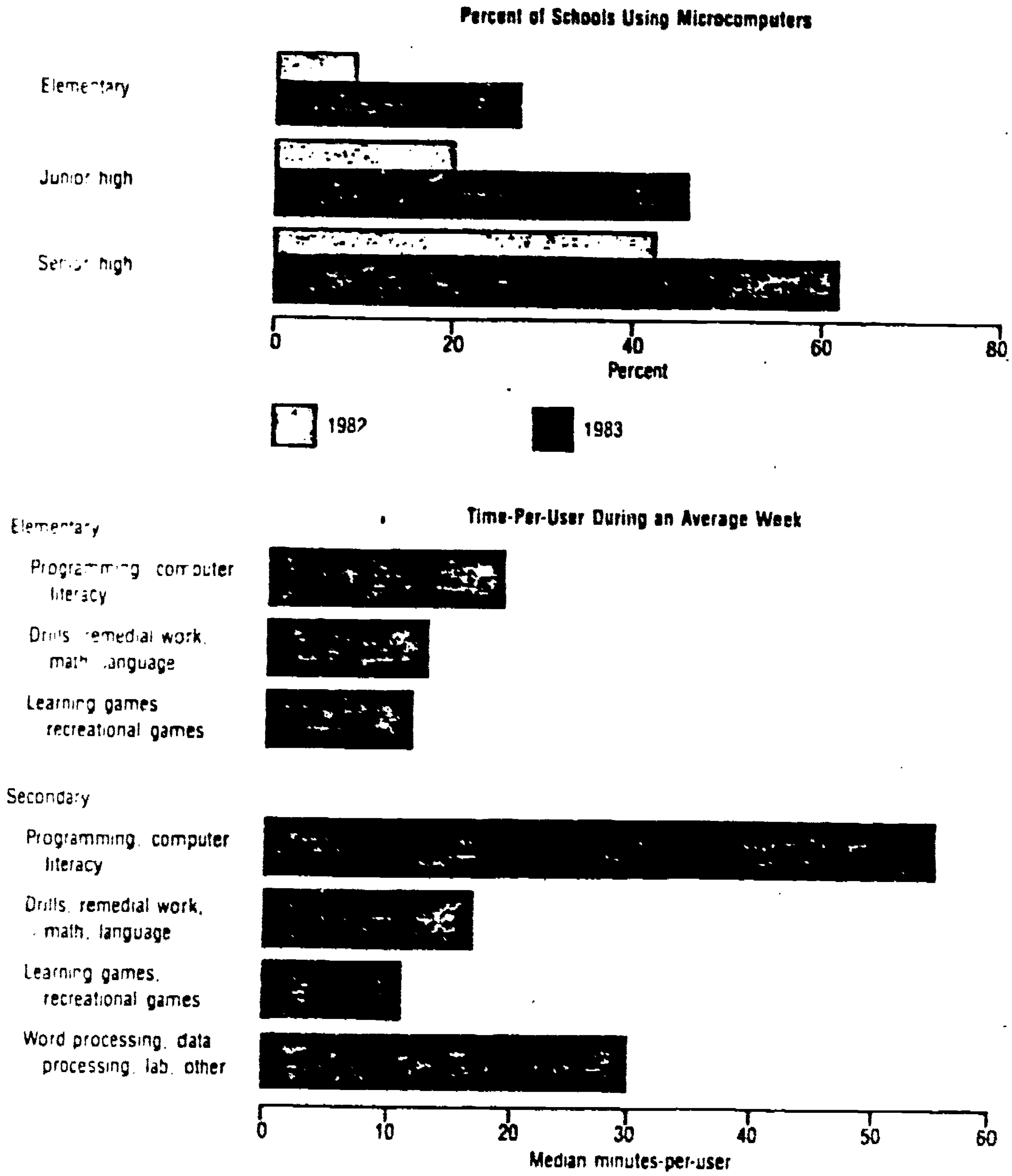
A. CURRENT PRACTICES

As indicated in Chapter I, in the next few years more schools will have more microcomputers available to students. This growth in hardware acquisition is occurring at all levels. As shown in Exhibit III-1, between 1982 and 1983 there was a 175 percent increase in the number of elementary schools using microcomputers.[51] The percentage of schools using microcomputers more than doubled at the junior high level and increased by 61 percent at the senior high level between 1982 and 1983.

1. USAGE PATTERNS

Although the availability of hardware is rapidly increasing, student contact time is increasing at a slower pace. The typical elementary school

Use of Microcomputers in Elementary and Secondary Schools



SOURCE: **The Condition of Education** 1984 Edition

Statistical Report
National Center for Education Statistics

student spends only about 20 minutes per week on a computer; the typical secondary student spends about 45 minutes per week on a computer. This short exposure time is clearly not explained by a shortage of computers. Even though a typical computer-using school has ten microcomputers, the typical microcomputer is used by students only two to three hours per day, less than one-half the time school is in session. Moreover, about one-fourth of the responding elementary schools report using their equipment less than one hour per day.

One reason for this apparent lack of use is that only a small percentage of the teachers in microcomputer-using schools are using the hardware. In about one-half of these schools, only one or two teachers are regular users of computers.[52] In other instances, computer use is restricted because hardware has been purchased with categorical funds targeted on certain student populations. In schools where substantial numbers of teachers are involved with the schools' computers, their involvement is often limited to packaged learning games or drill-and-practice software.

It is generally agreed that an optimum amount of time needs to be spent on any learning task to produce a positive effect on skills or knowledge mastered. Thus, the amount of time a student spends on CAI may have a considerable effect on the benefits received. Some experts believe that using the computer for 20 minutes per week is so brief as to make little difference in learning outcomes.[53, 54]

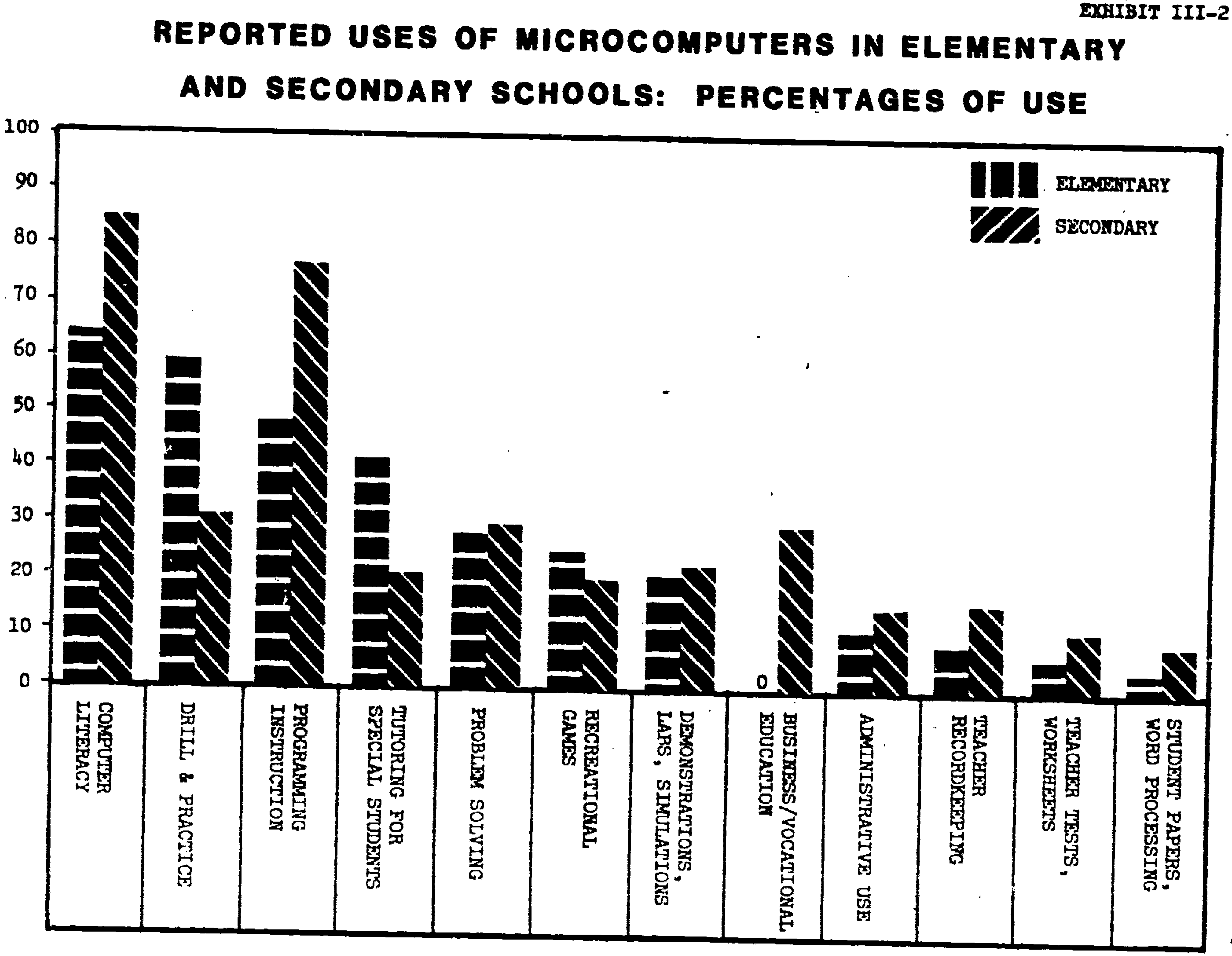
The current use of computers in public schools has not had a major impact on how students' time in school is spent. Drill-and-practice CAI intervention has, for the most part, been integrated into existing (elementary and junior high) remedial and special education programs. Although computers are increasingly being used in gifted and talented programs, they are often used for enrichment activities which, for the most part, existed before the availability of computers. A number of years ago, many school districts created "computer literacy" courses which were conducted in laboratory-type configurations. Such formal computer literacy courses have begun to disappear as tool applications are increasingly being integrated into existing content areas.

2. GRADE LEVELS AND CONTENT AREAS

Within local school districts, there are noticeable differences in computer use by grade level. Sixty-four percent of the elementary schools use computers to teach computer literacy or computer science compared with 85 percent of the secondary schools. On the other hand, the use of drill-and-practice CAI at the elementary level exceeds its use at the secondary level -- 59 percent to 31 percent. Exhibit III-2 displays computer usage comparisons between elementary and secondary grade levels in other areas as well.[55]

Trends in the uses of microcomputers are emerging. Schools that have used microcomputers for several years report a decline in the use of microcomputers for drill-and-practice as a percentage of total use. Among elementary schools that started using microcomputers before the 1981-82 school year, 21 percent

EXHIBIT III-2



SOURCE: School Uses of Microcomputers, 1983. Center for Social Organization of Schools, The Johns Hopkins University provide more computer drill-and-practice than anticipated; 35 percent report providing less instruction this way. Having declined only slightly at the elementary level, computer drill-and-practice has dramatically decreased at the secondary level. Moreover, schools with more microcomputer experience tend to increase computer use for teaching programming and "computer literacy". Elementary schools which, in July 1981, had used microcomputers for three years increased programming uses from almost 20 percent of total use in the first year to approximately 50 percent by the third year. Similarly, programming instruction in secondary schools grew from 40 percent in the first year to almost 70 percent of total use in the third year.[56] Although these findings are based on surveys conducted several years ago, it continues to be true that microcomputers in secondary schools are used primarily to teach computer programming and for tool applications (e.g., word processing). Elementary school uses of microcomputers, on the other hand, are less differentiated. Elementary schools report using their computers with about the same frequency for computer literacy purposes, to supplement instruction, for enrichment, and for drill-and-practice.[57] These changes in use patterns are attributable to several factors: (a) increased availability of tool applications; (b) outside pressures from parents and the business community to prepare youth for computer-related occupations; and (c) state and district mandates for a computer curricula to include programming. These factors will be discussed in depth in later chapters.

In general, elementary schools use computers most frequently in math, followed by language arts, reading, computer programming, social studies, science, and art. Math use has ranked highest over the last three years, but use in reading and language arts has increased. Secondary schools use their computers most frequently in computer science, followed by less frequent use in math, business subjects, and general science.[58]

3. EQUAL ACCESS

Findings from a national survey of recent studies suggest that schools, in general, are not making the best use of computers to provide learning experiences for all of their students. Girls and minority students are not enrolled in computer programming courses on an equal basis with white males. A study of more than 40,000 Connecticut high school students (conducted several years ago) concluded that the numbers of female and minority students enrolled in high school computer programming courses are disproportionately low compared to their incidence in the school-age population. The inequity seems to have little to do with ability, but with psychological barriers and subtle forms of stereotyping. Some studies have found that girls have less confidence in their mathematical abilities and often incorrectly assume that computer programming requires a math background.[59]

More recent studies do not support these findings of inequity. A University of Virginia study, examining the effects of age, gender, and computer experience on attitudes of high school students, found that gender was not significantly related to student attitudes toward computers.[60] A North Carolina study of elementary students concluded that race and gender affected student interest in computers only minimally. Student interest was related more to grade level, with older students reacting more positively than younger ones.[61]

4. HOME COMPUTER USE

A movement which is paralleling efforts of schools to use computers to enhance instruction is the use of home computers by parents to improve the education of their children. About 60 percent of the more than six million home computers are in households with children.[62] Educational use of the computer in the home is rapidly approaching the more common entertainment uses. Most owners identify instruction as their second most important use. Concern about the quality of the education their children receive in public schools has prompted the growth of the home education computer market; parents' general distrust in the schools' ability to prepare their children for a "high tech" world was given as a driving force for those families who use the home computer to supplement their children's education or replace the school altogether.[63] Among families buying home computers for educational purposes, 64 percent said they did so to get a head start on courses offered in school; 34 percent for additional courses that were not available in school; and 31 percent as remediation for children having academic difficulties.[64]

While schools may be in a position to assist parents with supplemental instruction at home, they are not, in fact, availing themselves of this opportunity. The schools that responded to a national survey are not very knowledgeable about what is going on in the home and have no plans for dealing with it. Although 50 percent of the schools that responded to the survey reported that school computers were available for use after school hours to families that did not own computers, only three percent of the districts had specific educational projects that connected computers at home with those at school. In addition, the one area in which parents noted the greatest problem was in the selection of quality software. Schools, however, typically have not directed efforts toward software evaluation and selection as indicated by an 86 percent response of "no policies" in this area.[65]

Home computers could increase the achievement gap between middle and lower income groups. Although the Federal, state, and local education agencies have different roles, they all must identify and address inequities in educational opportunity. If the growth in home computers continues, it is likely that parental pressure for cooperation between school and home computer-based instruction will continue to increase.[66]

B. EFFECTS OF COMPUTER-BASED EDUCATION ON STUDENTS

There is substantial evidence that computer-based education can have important positive impacts on both the performance and attitudes of specific types of students under certain conditions. It is important, however, that caution be exercised when applying the results of CAI effectiveness studies to the ways computers are actually being used in schools. The following points should be borne in mind:

- In the CAI effectiveness studies reviewed for this project, statistically significant findings of positive effects on student outcomes were present in projects which exposed students to computer-based instruction for at least ten minutes per day. At this time, there is no evidence to indicate that schools are providing sufficient exposure to computer-based instruction to make a difference in the performance of all students.

- In CAI effectiveness studies, the microcomputer was usually used for drill-and-practice at both elementary and secondary levels. Very little research has assessed whether computer-based instruction has had a differential impact upon students when it is used for different purposes (e.g., tutorial, simulation).

- Most of the studies reviewed have focused on gross comparisons between "traditional" instruction and computerized instruction. Traditional instruction in most cases was defined as one teacher lecturing to a large group, typically 20 to 30 students. Other methods of instruction, such as team teaching, peer tutoring, open classroom, etc. were not compared with computer-based instruction in these studies.

The body of CAI effectiveness literature has received criticism for several reasons. First, it tends to be unsystematic. Many studies were developed to evaluate a particular computer-based course in a specific setting with a limited audience. Furthermore, the various studies do not build upon one another and consist of many different CAI programs, evaluation designs, arrangements, and outcome measures. In particular, a research gap exists in studies investigating student characteristics (such as sex, race) and effectiveness of CAI. In addition, there is a lack of studies that systematically examine if and how the role of the teacher is affected when CAI is used for instruction.

The majority of the CAI effectiveness studies reviewed have other characteristics that may limit their correlations. Most of these investigations addressed mainframe or minicomputer systems; only a few studies involved delivery of computer-based instruction by microcomputer. Yet, it is the microcomputer that schools are purchasing. Finally, the content areas chosen for study in most of this literature were math, science, reading, and language instruction. Despite these limitations, results from CAI evaluations conducted over the past ten years have shown statistically positive effects in well-implemented programs.

1. COST/TIME SAVINGS

When compared to traditional instructional approaches, CAI has been found to reduce, by between ten an 30 percent, the amount of time needed for the average student to master similar objectives. As early as 1968, computers were linked with time and cost savings in education and training with the military and for students in secondary and post-secondary education. For example, in a study comparing CAI in electronics training for military personnel and a similar type of CAI in secondary education, the ten percent reduction in student time spent in training increased the rates of return on training investment, thus justifying the conversion to CAI of the existing electronic training courses. A study of computer-based training conducted in the military services indicated that the major benefit of CAI, compared to conventional instruction, is that it saves student time without loss of student achievement.[67,68]

Several studies conducted at the post-secondary level suggest that students using CAI take less time to learn as much or more as do students under traditional instruction. In one study, medical science students using CAI completed one semester of material in one-third to one-half the time of non-CAI students. The same study measured retention of concepts taught via computer and found, 26 weeks later, that CAI students showed greater retention than students who received traditional instruction.[69] Other investigations with college students showed statistically significant differences favoring computer instruction (3.5 hours of instructional time per week for conventional classes versus 2.25 hours for computer-based instruction).[70]

Findings from investigations at both the elementary and secondary levels reach similar conclusions. Younger students also appear to complete material faster on computers than off — occasionally as much as 40 percent faster. Studies conducted with secondary students revealed savings in time for student learning of as much as 88 percent.[71]

Whether these findings can be attributed solely to the use of CAI as a medium of instruction or to better formated and presented instructional content, however, is a matter of conjecture. Moreover, when CAI is compared to other effective teaching strategies (e.g., tutoring), the relative effectiveness of CAI is diminished.[72]

If no other positive effects were indicated with computer-based instruction, it appears that reduced learning time would make CAI cost-effective for public education. Although cost-benefit analyses are not common in the literature, one such analysis concluded that the costs of computer-based instruction were equivalent to the benefits that might accrue from equal amounts of tutoring.[73] The benefit of reduced costs for schools, however, can only be realized if instruction is individualized in such a way that students are allowed to progress through material at their own pace. Thus students can accelerate their learning rather than follow inflexible curricular time constraints.

While studies have compared the amount of time it takes to master a particular skill using a computer versus conventional instruction, they have not suggested an appropriate amount of time that students should spend on computer-based learning activities. More research is needed in the assessment of how much time using CAI is necessary for student performance to show significant positive results. Two studies, to date, have addressed time on CAI tasks and have concluded that, in the right settings using appropriate software, ten to 20 minutes per day of exposure to CAI produces significantly higher test scores than non-CAI experiences.[74, 75]

2. ACHIEVEMENT AND ATTITUDES

Positive effects of CAI have been found in other more pervasive areas than merely time savings. Students' achievement, attitudes, and social relations have been positively affected by computer-based instruction. In separate reviews of CAI effectiveness literature, similar conclusions were reached concerning the effects of CAI on performance and attitudes. It must be kept in mind that these studies measured outcomes only in specific ways (e.g., scores on standardized achievement tests and self-reported attitude scales). In addition, for the most part they used drill-and-practice software with relatively few subject areas (primarily foreign language, math, and some reading). A review of more than 20 studies led to the following conclusions:[76, 77]

- CAI provides students with individualized instruction which they often fail to receive in a large classroom setting;
- CAI is at least as effective as traditional instruction in 55 percent of the studies and more effective in 45 percent;
- the subject areas where CAI is most effective are: science and foreign language, mathematics, and reading/language arts;
- CAI appears effective when aimed at specific student body groups (e.g., high- or low-achieving students); however, lower achieving students require a longer period of time with CAI than do average or above-average students;
- when CAI is fully integrated into the curriculum, it is more effective;
- positive effects increase when the proper setting and scheduling are established (i.e., flexible scheduling, effective teacher training, principal support, individualized pacing); and
- student attitudes toward CAI and familiarity with it have a substantial effect on CAI's usefulness.

Positive achievement effects have been identified for students in elementary and secondary schools. Most impressive is the finding that CAI seems most effective for student achievement at the elementary level. Sixty-eight percent of the students from CAI classes outperformed the median student from the control classs on standardized achievement tests. Achievement results analyzed from approximately 30 studies conducted at the secondary level revealed that students from CAI classes performed at the 63rd percentile, compared to students not using CAI who performed at the 50th percentile on the same measures.[78]

Major evaluations were made of four large-scale projects using computer-based instruction: (a) the TICCIT project; (b) the PLATO demonstration; (c) the LAUSD project; and (d) IBM's Writing to Read project. Exhibit III-3 depicts these projects in terms of student age, numbers of students involved, hardware used, and outcomes studied.

In the Time-Shared Interactive Computer Controlled Information Television (TICCIT) project, community college students were taught mathematics and English using CAI. Achievement results indicated a ten percent improvement over conventional lecture sections for math and five percent for English. Attitudes toward subject matter were also affected positively.

Community colleges and elementary grades were the targets of the Programmed Logic for Automated Teaching Operations (PLATO) demonstration. For the community college sample, a series of analyses yielded significant positive

COMPARISON OF FOUR LARGE-SCALE CAI EFFECTIVENESS STUDIES

	STUDENT AGE LEVEL	NUMBERS OF STUDENTS INVOLVED	HARDWARE	OUTCOMES STUDIED
TICCIT	COMMUNITY COLLEGE	5,000	MAINFRAME	• RATES OF COURSE COMPLETION • ACHIEVEMENT • ATTITUDES • STUDENT ACTIVITIES
PLATO	COMMUNITY COLLEGE	4,000	MAINFRAME	• ACHIEVEMENT • ATTITUDES
	ELEMENTARY	1,000		
LAUSD	ELEMENTARY STUDENTS IN COMPENSATORY EDUCATION	APPROX. 3,000	MINICOMPUTER	• ACHIEVEMENT • ACHIEVEMENT OVER PERIOD OF TIME
IBM WRITING TO READ	PRIMARY (KINDERGARTEN, GRADE ONE)	10,000	MICROCOMPUTER	• ACHIEVEMENT • ATTITUDES - STUDENTS - TEACHERS - PARENTS

differences between PLATO and control classes in course completion. Positive achievement effects appeared in mathematics, chemistry, and biology. Further, the attitude items revealed a favorable impact of the PLATO demonstration on the attitudes of both students and instructors. The PLATO demonstration conducted at the elementary level involved 300 students in mathematics and approximately 700 who received reading lessons through CAI. In math, significant positive effects were found at all grade levels (i.e., 4, 5, 6). These effects were greatest for topics emphasized by both PLATO and the teacher. Attitudes toward subject matter tended to be more positive in the PLATO group than in the group that received conventional instruction. Increases in attitudes toward subject matter were greater for math than for English.

The third study evaluated by ETS was a four-year longitudinal study of elementary students involved in compensatory education -- Title I classes -- in the Los Angeles Unified School District (LAUSD). Computer labs for the study were equipped with terminals controlled by a minicomputer. CAI was provided by drill-and-practice software in math and in reading and language arts. Findings of the LAUSD study included positive effects of CAI in achievement and attitudes. In math, with exposure times averaging ten minutes a day, CAI students showed significant positive effects in computational skills compared with control students. With 20 minutes per day, computational skills were doubled. Additionally, longitudinal data revealed continued and increasing gains in computational skills. In the reading and language arts areas, smaller but consistently positive results were obtained. A major finding of the LAUSD study involved effects on attitudes. Attitudes toward reading and feelings of internal responsibility for success were significantly higher among students who received CAI than among students who did not. The conditions under which the CAI was implemented in the LAUSD study are associated with successful practices identified in other instructional effectiveness studies (i.e., not of computer-based learning). These conditions include:[79]

- mastery learning;
- high academic learning time with a high probability of success in responding;
- direct instruction;
- adaptability and consistency of instruction;
- an orderly atmosphere with expectation of success in basic skills; and
- use of drill with equal opportunity for responses from all students.

The last study evaluated was an evaluation covering more than 10,000 kindergarten and first grade students in 21 sites in the first year. In the second year, the study concentrated on a core sample of 3,210 students using IBM's Writing to Read program with microcomputers and 2,379 comparison students in classes not using the program.[80, 81] Results of the study indicated that:

- For writing achievement, in 29 of 33 Writing to Read schools, the program had a positive impact on writing skills.

- For reading achievement, 22 of 27 Writing to Read schools showed a positive impact on reading.

- Fifteen percent more parents reported greater progress in their children as compared to parents of the non-Writing to Read groups.

In general, it appears that well-implemented CAI programs consistently produce statistically significant gains when compared with control groups and/or previous learning rates of students (implementation variables are discussed later in this chapter).

3. COMPUTER-MANAGED INSTRUCTION

Computer-managed instruction (CMI) and its impact on students has also been studied. When student performance is compared to cost, there are advantages of CMI over CAI because less hardware and software are required for its use.[82, 83] When CMI is used in special education, moderate to significant savings in staff time accrue and paper work is reduced. For example, one study found that use of the Modularized Student Management System (software for managing special education) reduced the average amount of time spent by a teacher in updating Federally-required individualized education programs (IEPs) from 70 minutes to 12 minutes per student.[84] Another study reported relative time savings of about 50 percent when comparing computer versus noncomputer-based IEP development.[85]

Many of the observed positive effects of computer-assisted instruction reflect the use of CMI systems. Indeed, many of the CAI studies reported earlier were supplemented by such CMI applications as student progress monitoring. When elementary-aged student achievement measures (as opposed to time savings for teachers) are the outcomes being measured, CMI does not have as great an impact as CAI. In four studies of elementary children that compared student outcomes of two groups -- one using CAI and the other using CMI -- the achievement effects of CAI were more positive than those of CMI. This finding is not surprising because CMI is designed to exploit different features of the computer than CAI. It keeps records on student progress and often assists in diagnostic testing and screening functions. A form of individualized instruction, CMI (when used directly with students) allows learners to pace themselves, work independently, and make their own choices. Young children in the elementary grades may not have developed the skills and motivation for these requirements. Computer-managed instruction has had the greatest impact at the higher grade levels, such as in secondary and post-secondary settings.[86]

C. EFFECTS OF COMPUTER-BASED EDUCATION ON TEACHERS

Teachers' attitudes toward computer-based instruction and management have implications not only for how computer-based instruction will affect students but also how teachers could influence the design and development of programs by the software publishing industry. Only a few limited investigations, to date, have addressed this topic.

In one 1982-83 survey, microcomputer-using teachers indicated a belief that the greatest impact of microcomputers on students has been social. Obtaining a fair response rate (68 percent), researchers found that 30 percent of the responding teachers believe that computers have led to increased student enthusiasm for schooling. Only 18 percent felt that students worked more independently, without assistance from teachers (probably because the available software was not designed for independent student use). Twenty-four percent of the surveyed teachers (elementary and secondary) believed that above-average students have learned more than average or below-average students.[87] This view is different from earlier investigations that concluded CAI was more effective with low-achieving students possibly because, in part, of the type of computer-based instruction used in these schools; since computer programming was emphasized, as opposed to drill-and-practice, higher functioning students would naturally perform better than students functioning below grade level.

Teachers' attitudes toward the use of computers with low-achieving students were found to be positive when implementation efforts occurred in an organized manner. Although some school staff were initially intimidated by the presence of new computer equipment in classrooms, their attitudes became more positive with time. The initial appearance of the microcomputer was viewed as an inconvenience -- a disruption of the flow of daily activities. But, by the end of the first year, most teachers were convinced of the value of CAI and supported it fully. In fact, in 1982, two years after government support for the project ended, the Los Angeles Unified School District continued operating its CAI program.[88]

In the 1982-83 school year, 82 percent of the teachers in a national survey felt that computers could help teachers be more effective. The majority of respondents also strongly agreed with statements suggesting that principals and teachers need help in planning for the demands brought about by computer technology.[89]

A more recent national survey, conducted with 5,000 teachers and 1,000 administrators, revealed that approximately 85 percent of the respondents displayed a generally positive attitude toward microcomputers. One must exercise caution, however, as these results were based on a response rate of only 26 percent. This study asked teachers and administrators whether they prefer newer computer technology to more traditional materials. The proportion of teachers who were "happy" to see new technologies enter the classroom grew from 74 percent in 1982 to 80 percent in 1983 to 86 percent in 1984. When teachers were asked to make a choice between the microcomputer and more familiar modes, their attitudes seem less favorable toward computers; 43 percent in 1983 and 48 percent in 1984 would choose a microcomputer over supplementary materials. Furthermore, when teachers were asked if they would rather have a microcomputer than new textbooks, responses indicated that very few teachers would make this choice (29 percent in 1983 and 29 percent in 1984). The results from this survey have implications for computer and related expenditures in public schools.[90] Questions must be asked about school expenditure trade-offs. First, if money is being used for acquiring new computer technology, is it coming from supplementary materials and textbook funds? Second, are these trade-offs reasonable in light of what we know about the effectiveness of CAI/CMI and teacher attitudes? Finally, how are policy makers, who are reacting to increased outside pressures to put computers in schools, to address the apparent reluctance of teachers to replace their major mode of instruction?

Teachers and administrators view computers in a positive light when computer-based learning packages are integrated with regular curriculum materials. There is emerging evidence that educators' attitudes are moving in a positive direction and seem to be related to exposure and familiarity with computers.[91]

D. IMPLEMENTATION VARIABLES

Clearly, current research findings indicate that computer-based instruction can increase student achievement in certain areas when quality courseware is used and when the programs are planned and implemented in an effective manner by school staff. Findings in studies which report that CAI is not as effective as conventional instruction usually also report that the conditions for effective implementation were inadequate.[92] Among such conditions are the quality of the software and organizational factors.

1. QUALITY OF SOFTWARE

The use of quality software is a necessary condition for improving student performance; however, by itself it is not sufficient. Summarized below are the characteristics of successful quality software which have been identifed by researchers and successful computer-using teachers.[93, 94] Such software must:

- allow for easy operation;
- be accompanied by clear documentation;
- provide opportunities for students to control the learning process;
- provide interaction, feedback, and often rewards;
- allow students and/or teachers to establish goals and provide self-evaluation;
- allow diagnosis of conceptual difficulties with materials and prescriptive branching;
- use the full range of hardware capabilities such as graphics, sound and color, etc.;
- include important concepts, if curricular in nature, as well as facts related to subject matter;
- allow for easy integration, if supplemental, into curriculum; and
- include, at a minimum, student record keeping capabilities, if curricular in nature, and monitor student progress.

2. ORGANIZATIONAL FACTORS

An additional element is increasingly being correlated with positive student outcomes and positive teacher attitudes when using computer-based instruction. This element includes the organizational conditions under which CAI is implemented. The conditions associated with successful use of CAI are summarized below.[95, 96, 97, 98, 99]

- School/Classroom Environment:
  - flexible scheduling of students and individual student self-pacing;
  - targeted use with specific populations (e.g., handicapped, gifted, slow learners);
  - opportunities for integrated use of hardware and software in a classroom setting, rather than a laboratory-type setting;
  - active support of computer use by the principal, who also perceived his/her role as instructional rather than administrative;
- Decision Making:
  - selection of specific courseware and, to a lesser extent, hardware in a participatory process involving key individuals (teachers) in the implementation process;
  - decentralized and flexible decision making during implementation, especially at the classroom level;
- Training:
  - teacher training in the use of specific courseware packages and/or applications prior to actual use in the classroom;
  - for CMI programs, teacher training in the functions related to instructional management and individualized instruction;
  - timely in-service training and follow-up support for instructional staff;
  - training provided by persons who are or have been in similar teaching situations.

As more CAI research is conducted and findings disseminated, it is likely that future courseware capable of being customized for local school districts' curricula will include comprehensive plans for implementing such systems.

E. PROJECTED EFFECTS

It can be anticipated that, in the next few years, the use of computers will have a number of important effects on the performance of students. Specifically affected will be student achievement, attitudes, and time-use patterns.

Policy makers, educators, and developers are beginning to ask why computer technology appears to enhance learning in students. Future effectiveness research will more stringently question student performance increases and what phenomena foster positive attitudes in students. As researchers and developers become less seduced by the hardware itself, it is likely that other variables known to have an impact on learning will emerge as vital to the success of computer-based instruction.

1. ACHIEVEMENT

In the last third of the decade, the relative effectiveness of computer-assisted instruction will increase dramatically in well-implemented instructional intervention with specific populations. The research on which these findings are based, however, will be questioned for a number of reasons:

- The quality and comprehensiveness of evaluations will be less than desirable. The level of funding required will not be available within the budgets of local school systems.

- As a result of the increasing prevalence of microcomputers in schools and in homes, it will be increasingly difficult to compare, for example computer-assisted instruction with "conventional methods". Many of these conventional methods will be contaminated from a research perspective because it will be difficult to control access to computers either in school or at home.

The notion of using national standardized achievement tests as a measure of student performance will be questioned. National and state tests which measure acquisition of facts and memory skills of students will be considered increasingly irrelevant in light of the new knowledge acquisition processes made available through microcomputer and telecommunication technology. Software that provides practice for taking standardized achievement tests will clearly demonstrate its effectiveness in increasing student scores on national tests used for high school graduation and/or college admission. As sophisticated courseware simulations, particularly at the secondary level, become available during the last third of the decade, students, parents, teachers, and administrators will realize the opportunities technology provides for performance-based measures of student mastery of concepts, critical thinking skills, etc. By the end of the decade, measures of student performance will become performance- or skill-based, using the computer to assess skill mastery.

2. ATTITUDES

Virtually all studies have found positive student attitudes related to computer-based programs. To the extent that the novelty of the computer contributes to these positive student attitudes, such attitudes will deteriorate over the next few years as the novelty effect wears off. Student attitudes toward computer-assisted instruction in the long run will be a function of the quality and type of software that is available in schools. Indeed, attitudes toward school-based CAI among students, who have access at home to more varied and higher quality software, may deteriorate for at least two years, until higher quality software becomes accessible and affordable to schools.

3. TIME-USE PATTERNS

Assuming that schools continue to acquire hardware at the current rate, by the end of the decade the ratio of microcomputers to students will be as high as one computer for approximately 20 students. This estimate is based upon an assumption that market saturation will occur at the elementary level with approximately 25 microcomputers per school and at the secondary level with approximately 30 microcomputers per school. The length of time a typical elementary student uses the microcomputer will increase from approximately 20-25 minutes to 50-75 minutes per week. At the secondary level, courses involving computer use will increase the length of time computers are used each day to as much as three hours. More extensive use at the secondary level will be attributed to: (a) the availability of sophisticated simulation courseware which can be used in social studies, business, and science courses; (b) the increasing use of tool applications and education-related data bases through low-cost telecommunication networks; and (c) more intensive computer use by computer-using students. By the end of the decade, the ratio of microcomputers to students will become less meaningful, as the computer itself will become relatively transparent in telecommunication and videodisc configurations and as students have greater computer access in other environments.

During the next three years, student time patterns in the schools will be affected, not so much by the increased use of computers as by state-level policy and reforms. A large number of states have expanded credit-hour requirements in math and science as a prerequisite for graduation. In some states, these increased requirements will be achieved by lengthening the school year or school day. In most states, however, these new requirements will be at the expense of other course areas (e.g., vocational education) or electives. For a variety of reasons, including the lack of subject matter specialists (e.g., science and math teachers), the microcomputer will be viewed as an integral part of some curricula, especially at the secondary level, as new simulations and other courseware become available.

By the end of the decade, the nature of the equity problem will be more qualitative (e.g., the types of courseware available to certain groups) than quantitative (e.g., numbers of students with access to computers). Although the numbers of students using computers will give the appearance of "equal access time", a more subtle form of inequity may exist with computer technology and applications highlighting unequal treatment of students. Examples of such imbalances are: (a) limiting slower students to using only drill-and-practice software and not exposing them to more sophisticated learning activities; and (b) the low proportion of cultural minorities and limited English proficient (LEP) children who use computers for learning activities.

By the end of the decade, student time usage patterns will be considerably different from those currently observed in schools. The distinction between formal education and informal learning will become blurred as students will increasingly have access to computers both during school hours and after school. In addition, through information utilities, software subscription services, and telecommunication networks, students will have access to a far greater range of software at lower costs. Moreover, graduation requirements will become increasingly mastery-based and students will have opportunities to take a larger number of electives for a variety of purposes, including: (a) preparation for advanced placement testing; (b) part-time or full-time employment opportunities; and (c) entertainment or recreation. The growing accumulation of knowledge, the low cost of information storage, and the ease by which information can be accessed will force schools to provide more individualized, self-paced instruction and a wider range of offerings.

4. IMPACT ON TEACHERS

Teacher attitudes toward computers will become more positive in the next three years as: (a) the installed base of microcomputers in schools increases and more teachers are exposed to them; (b) their expertise in evaluating courseware and integrating courseware into their curricula increases; (c) high-quality simulations and other courseware (which can easily be integrated into curricula) become available to them; and (d) they are involved in the planning stages of the implementation of computer-based instruction. Many teachers will continue to view CAI drill-and-practice as a means to reduce boring, repetitous teaching and as a babysitter for disruptive students or slow learners. Increasingly, however, teachers and administrators will view the microcomputer as a job aid to assist them in managing individualized instruction and to reduce time devoted to routinized activities and paper work.

Implementation of CMI systems must be preceded by extensive and in-depth training of all instructional staff, principals, and key administrators, particularly in the area of individualized instruction. Over the next three years, one might reasonably expect heightened interest in CMI systems as: (a) school staff see CMI as a means to assist in integrating appropriate supplemental courseware into existing curriculum; (b) state departments of education take a greater leadership role in attempting to ensure effective use of technology at the local level; and (c) more and more high quality comprehensive CMI and curriculum management packages become commercially available, often as a result of state-wide software adoptions.

During the early 1980s, the computer-buff teacher played a pivotal role by influencing building administrators to purchase computers. More recently, however, such decisions have more frequently been made by formal and informal committees at both the district and school building levels. While hardware decisions are gravitating toward the district level, many software decisions still remain at the building level, with teachers and principals having considerable influence over selection decisions. In the next three years, state- or district-level policy decisions related to technology use will have varying impacts upon teachers' perceptions of decision making and control. As education utility concepts are implemented and as the technology, memory capacity, and other technological features of these utilities improve, courseware options will increase dramatically to such an extent that teachers and principals will be increasingly forced into a decision-making role with the effect of major role changes for teachers.

If effective implementation of computer-based education is to occur, the general perception of the teacher's role will have to change from that of a deliverer of instruction to one of a manager of the learning process. During the remainder of the decade, as a result of state or district policy, technology will be viewed as an element of staff productivity. It will be increasingly used to measure and evaluate staff performance as a basis for career ladder schemes (including merit or incentive pay) presently being planned or implemented in approximately 25 states. Concurrent with this role change will be increased staff differentiation with specialized roles for aides, "media planners", and new positions which will emerge.

IV. COMPUTER LITERACY AND POST-SECONDARY EDUCATION

This chapter consists of an assessment of the importance of young peoples' computer use in school to their prospects for post-secondary education. It reviews the ways in which "computer literacy" is viewed in the context of computers in education. It then reviews the impact of computers on post-secondary education institutions and discusses computer literacy requirements for college entrance.

Few surveys have been conducted with representatives from either business and industry or post-secondary education and training institutions. Information for the study has been gathered from: conversations with occupational analysts; reports from panels; dialogues among educators and business leaders; and discussions with representatives of the Association of Societies for Training and Development. These conversations point to a critical need for research on how different occupations are defining computer literacy. Furthermore, aggregated information must be collected from colleges and universities to assess more accurately what skills constitute computer literacy and whether computer literacy will, in fact, become an overall admissions requirement.

A. COMPUTER LITERACY

Both the concept and definition of computer literacy have changed dramatically during the last eight years and can be expected to continue to change over the next decade. Moreover, the concept of "computer" literacy will be replaced by "technology" literacy as the distinctions among computers, telecommunications, and other information technologies blur. The factors responsible for the changing nature of the concept include the following:

- advances in hardware technology;
- improvements in software, which expand their range of applications and their ease of use;
- maturation of school staff and students in the use of computers;
- the osmotic effect of the increasing proliferation of microcomputers in business, homes, and society generally; and
- policy initiatives undertaken by state education agencies in the area of accreditation and suggested/mandated competencies for students as graduation prerequisites.

1. IN THE BEGINNING

During the late 1970s, most decisions to use microcomputers in schools were made by computer-buff teachers -- usually in the math or science area -- and, to the extent these teachers used a computer as an object of instruction, the "computer literacy" course was usually idiosyncratic to each teacher's concept of computer literacy. In 1977, fewer than ten school districts had formal computer literacy courses with guidelines and objectives organized in a structured curriculum.

Beginning in 1980, an increasing number of school districts began to develop courses on computer literacy, generally at the junior and senior high levels; most were electives. In 1980, one state (Minnesota) had written guidelines for a suggested (not mandated) course on computer literacy. It was around this time that the debate about computer literacy began to surface. One school of thought, reflected in the writings of Arthur Luehrmann, argued the critical need for teaching programming as part of computer literacy. In the words of Luehrmann, "if you can tell the computer how to do the things you want it to do, you are computer literate". This school argued that computer literacy should be taught in laboratory-type situations and should include programming. The other school of thought[100] argued that computers should be considered a tool and that students need only be able to use the tool to work effectively in the information age. Given the vigor of the debate and the lack of definitional consensus, a survey was conducted in 1982 of computer-using schools to identify what topics could loosely be categorized as computer literacy.[101] The results of this survey, summarized in Exhibit IV-1, indicate the percentage of respondents who included specific topics in computer literacy courses for students.

Beginning in late 1982 and throughout 1983, a number of states began to address the concept of computer literacy from a policy perspective and began to influence local implementation of computer literacy courses through guidelines, standards, and graduation requirements. Generally speaking, in those states where governors and legislatures were attempting to tie computer literacy to the development of "high tech" centers, computer literacy was more programming-based than in other states. In these programming-oriented computer literacy programs, LOGO was the language taught at the elementary level; BASIC and PASCAL were taught at the junior high and high school levels. In states where computer literacy concepts were developed by state education agencies in consultation with local districts, computer literacy was defined operationally in three categories: (a) awareness of and orientation to computers, including history; (b) functional or practical applications; and (c) advanced applications, including programming and software development. In virtually all cases, Category (a) -- and to a lesser extent Category (b) -- were recommended for students by the completion of junior high school; Category (c) was generally tied into computer science courses, most frequently as an elective at the high school level. In any case, states were recommending, and schools were implementing, formal or informal courses referred to as "computer literacy".

Beginning in late 1983 and early 1984, the concept of computer literacy underwent a significant change, especially in those states where no previous policy had been finalized. The rapid availability of commercial tool application packages (e.g., spread sheets, word processing, and similar packages) and the prevalence of microcomputers in regular classrooms (as opposed to computer laboratories) increasingly provided opportunities for creative teachers to integrate these tool applications into existing courses in math, science, reading, writing, etc. This phenomenon was observed at both elementary and secondary levels. Only in those states (e.g., Tennessee, Rhode Island) with formal policies -- such as credits for graduation and formally accredited computer literacy courses -- has the concept of formal, laboratory-type computer literacy courses grown relative to integrated computer use.[102]

PERCENT OF SCHOOLS COVERING EACH TOPIC IN A COMPUTER LITERACY COURSE

TOPIC	PERCENT
COMPUTER OPERATION	53
PROGRAMMING IN BASIC LANGUAGE	53
PROGRAMMING IN OTHER LANGUAGES	8
HARDWARE AND SOFTWARE CONCEPTS	41
DATA PROCESSING TECHNIQUES	19
HISTORY OF COMPUTERS	34
PRACTICAL COMPUTER USES	43
ROLE & IMPACT OF COMPUTERS IN SOCIETY	35
COMPUTER CAREERS	36
OTHER TOPICS	8

2. AT PRESENT

In 1983, an attempt was made to define computer literacy and to develop items which could be included in a national assessment.[103] The members of the panel did not arrive at consensus on a definition of computer literacy, although they did develop item pools for subsequent national or state surveys. The components of computer literacy which they developed highlight the belief that literacy will vary from person to person, from job to job, and from time to time. It is unlikely, therefore, that today or in the immediate future there will be a universal definition of computer literacy. Operationally, the concept will be defined by the policies, standards, objectives, and guidelines of individual states and school districts.

Schools, however, are being encouraged to standardize computer literacy, as evidenced by the first nationwide assessment of computer competency for students scheduled for Spring 1986. The computer competencies of some 39,000 students ages 9, 13, and 17 in 30 states will be measured. The addition of computing to the list of subjects periodically assessed by the National Assessment of Educational Progress (NAEP) -- which includes science, mathematics, social studies, music, and art -- represents a "coming of age" for computing, said Marc Tucker, head of the assessment committee.[104] What remains to be determined is the quality of planning upon which these local policy decisions are based. Establishment of specific computer literacy standards, however, assumes that computer-related technology is static. Policy makers need to accept the changing nature of the technology and to develop practices consistent with adaptation to change.

3. ON THE HORIZON

In the next four to five years, a number of factors and events will continue to affect the nature of computer literacy course offerings at the local level and the type of computer skills which students will acquire formally in the public schools.

Some technology experts believe that, by the end of the decade, the notion of computer literacy will largely disappear as educators and policy makers recognize that the computer is only one tool for survival and productivity in the information age. "Technology literacy" will emerge as the convergence of telecommunications and microcomputers blurs traditional lines of demarcation. In many states west of the Mississippi, where telecommunications is an important education policy issue and systems are generally in place, this is already occurring.

Tool applications software will continue to be integrated into regular subject matter offerings. The high rate of acquisition and use of tool applications in the public schools will continue at all levels for the foreseeable future. Moreover, during 1985, some publishers will announce instructional courseware packages which can be used by teachers and students to tap into commercially available data bases (e.g., UPI, Dow-Jones) which have heretofore had little use in education. The availability of these packages, along with low-cost disc storage at the school building level, will increase opportunities for data base use while reducing costly telephone connect-time charges.

Despite the availability of user-friendly hardware and software, a major barrier to acceptance will be the lack of teacher experience in the integration and use of tool applications in curricula. In 1980, only three teachers colleges in the country had specific courses on computer use in education. In March 1983, a national survey found that approximately 40 percent of the states had no teacher education institution with computer literacy as part of its program. Indeed, to the extent that the computer literacy courses conducted by many colleges and universities have been heavily influenced by departments of computer science, many "computer literate" teachers may have to be given additional training, focusing on the use of tool and instructional management applications in the classroom.

Because of the evolving nature of technology and the changing applications of computers, some experts believe the creation of a national definition or national standards for computer literacy is neither necessary nor desirable. Further, the inclusion of computer literacy domains and items in national standardization tests are likely to be counterproductive and could encourage school districts to teach obsolete concepts. The education community has decided that some knowledge and skills pertaining to computers should be imparted to its students. The important question must be asked: Are the schools' computer literacy requirements grounded in the needs of students as they leave secondary education?

B. COMPUTERS AND POST-SECONDARY EDUCATION

Almost as many high school graduates go on to college as enter the work force and the military. Several different types of post-secondary educational institutions exist in the United States: (1) vocationally-oriented, noncollegiate post-secondary schools; (2) community (usually two-year) colleges; and (3) four-year colleges and universities.[105] Training issues in noncollegiate post-secondary institutions are addressed in another report sponsored by the NCEP and entitled "Training for Work in the Computer Age" (National Institute for Work and Learning, 1985) and are not within the purview of this study. To avoid duplication of efforts, this discussion focuses on the academic institutions.

1. COMPUTER ARRANGEMENTS ON CAMPUS

At present, a few dozen universities are actively placing computers in the hands of students; hundreds more are exploring such possibilities. Some active institutions are incorporating personal computers as part of tuition. In some such instances, equipment has been donated to the university by equipment vendors; in other instances, universities have worked out discount arrangements with vendors for group purchases; in still other cases, universities have purchased computer hardware for specific course offerings. These donations and discounts are particularly prevalent from vendors with small shares of the higher education computer market. In some instances, large university-wide contracts with vendors provide opportunities for individual professors and students to purchase microcomputers for personal use.

Other factors have also influenced the computer policies of post-secondary institutions. Colleges and universities have purchased microcomputers largely because the older time-sharing (mainframe and minicomputer) systems lack sufficient storage capacity, are expensive to upgrade and maintain, and are often not readily accessible. Moreover, because high school seniors are increasingly being prepared to use computers, they are demanding more ready access to computers in college. Survey results from the American Council on Education reveal that more than one-half of the freshmen who entered state universities in 1983 had written at least one computer program, and about one-third had taken at least one computer-assisted high school course.[106]

Many colleges have plans to create networks of microcomputers on their campuses in order to increase the computing power available to students and to increase communication among students and faculty.[107] Networks are systems whereby the personal computers are linked together on a local basis. Networks can deliver electronic mail, display student bulletin boards, supply information services and electronic library catalogues, and provide communication among users. Administrators, students, and faculty are beginning to view the computer less as a computing machine and more as a tool to be used for broader applications. This is evidenced by the recent surge of university departments -- other than engineering and computer science -- requiring students to use personal computers for such functions as word processing in English departments and spread sheets in business departments. For example, Colorado State University began a project in 1981 in which students in English classes used the Bell Laboratory Writers Workbench series, a powerful word processing program. The Writers Workbench series was the first extensive collection of computer programs for textual analysis. Originally designed for professional writers at Bell Labs, the program was adapted by Colorado State for use by college students.[108] The success of the project has caused other universities to use Writers Workbench in their English departments.

2. CAMPUSES INVOLVED IN PERSONAL COMPUTING

Although a relatively small number of colleges to date have formally implemented computer use, there is evidence that more institutions will follow suit. Larger private institutions, with their greater financial resources and administrative flexibility, have led the campus microcomputer movement. Exhibit IV-2 depicts the 15 colleges considered to be early adopters of widespread computing on campus.[109, 110]

Shown in Exhibit IV-2 are some of the differences that exist among schools with regard to implementation methods and major uses of computers. Only six of the institutions actually require freshmen to have personal computers; others have stationed clusters of computers or work stations around the campus for use by any student. Still other institutions have purchased large numbers of microcomputers for sale to students at discounted prices to encourage computer use. Hardware selection also varies. Most colleges surveyed have selected a single system. Others have made the decision to enter into agreements with various vendors based on the assumption that no single make of microcomputer could meet the needs of all students and staff.

Although a detailed list of all the uses of personal computers is not incorporated into the matrix (Exhibit IV-2), certain uses are coming to the forefront. Almost all schools are networking local microcomputers together and/or to existing mainframe systems. Increased communication among faculty and students is given high priority in these colleges. The number of schools

INSTITUTIONS OF HIGHER EDUCATION
AND PLANNED USES OF PERSONAL COMPUTERS

INSTITUTIONS	IMPLEMENTATION METHODS				MAJOR USES			
	Require Personal Computer for Students *	Work Stations	Single System (Hardware)	Multisystem (Hardware)	Networking	Software Development by Faculty	Integration into Curricula	Research
1. Massachusetts Institute of Technology (Cambridge, MA)		X	X		X	X	X	X
2. Carnegie-Mellon University (Pittsburgh, PA)	X		X		X		X	
3. Clarkson University (Potsdam, NY)	X		X		X	X	X	
4. Stevens Institute of Technology (Hoboken, NJ)	X		X		X	X**	X	
5. Rochester Institute of Technology (Rochester, NY)				X	X		X	
6. Rennsselaer Polytechnic Institute (Troy, NY)	***				X		X	X
7. Case Western Reserve (Cleveland, OH)		X	X					
8. Stanford University (Palo Alto, CA)		X		X	X	X		
9. University of Michigan (Ann Arbor, MI)		X		X	X		X	X
10. Drexel University (Philadelphia, PA)	X		X		X			
11. Brown University (Providence, RI)		X		X			X	X
12. Dartmouth College (Hanover, NH)			X		X	X	X	
13. Reed College (Portland, OR)			X		X			
14. Dallas Baptist College (Dallas, TX)	X		X				X	
15. Drew College of Liberal Arts (Madison, NJ)	X		X				X	

* Incoming Freshmen
** Encourage joint software development among faculty and students
*** In future plans, when network in place

integrating computer use across curriculum areas make apparent the shift from specific engineering and computing uses to broader applications. A recent national survey of colleges and universities found 66 percent of representative faculty members indicated that either they or someone else in their department used computers in conjunction with a course being taught (including both instructional and administrative uses). Another 20 percent indicated future plans to use computers. When further broken down by departments, academic computer use was prevalent with 91 percent of business departments; followed by 88 percent of math and computer science departments; 83 percent technical and agricultural departments; and 81 percent of science departments. Education departments outpaced the other less technical disciplines with 75 percent reporting current computer use; followed by 63 percent of social science departments; 43 percent of health-related departments; and 42 percent of humanities departments.[111] Other colleges and universities are also encouraging computer use; among these are: the University of Maryland, Colorado State University; University of Illinois, Milwaukee Area Technical College, New Jersey Institute of Technology; and Virginia Polytechnic Institute ... and the list is expected to grow.[112, 113]

Information regarding the impact of computers on community colleges is not as precise as the picture of four-year colleges and universities. There are 12,000 community and junior colleges in the United States. In a recent national survey, nearly 90 percent of the institutions surveyed report using computers in instruction. While computer uses vary (e.g., automated job banks, satellite communication, software-sharing consortia, interactive videodiscs), precise implementation methods have not been studied. There is, however, no question that computers have arrived at two-year colleges. Research concerning instructional applications is so scant in this area that the only discernable pattern is that larger community colleges use mainframe systems, while smaller institutions have stand-alone microcomputers.[114, 115]

3. SKILL REQUIREMENTS FOR COLLEGE COMPUTING

It is difficult to assess the number of college departments that now require computer-related skills for entrance. One survey of 50 colleges found few absolute requirements. Members from six academic departments (i.e., computer science, mathematics, engineering, business, science, and liberal arts) at each college were surveyed, with 78 percent of the 50 schools responding. Findings from the survey indicate that computer-related entrance requirements do exist for some departments within colleges; however, overall admission requirements are far less likely to occur. The skill most needed was typing (29 percent required; 67 percent nice to have), and specific backgrounds in BASIC (nine percent, 67 percent), PASCAL (seven percent, 63 percent), or FORTRAN (eight percent, 64 percent) was most desired.[116]

More than one-half of the institutions which responded indicated that neither a knowledge of the history of computers and their social implications, nor an ability to write programs was required. Feedback from additional comments on the survey revealed that the respondents felt incoming college students should have improved backgrounds in reading, writing, and mathematics skills.

Although this survey did not provide evidence to suggest an overall computer literacy requirement for college admission, it was limited to those colleges which received the most applications for admission from a single high school (New Trier, Illinois). Moreover, the survey was conducted in 1982; with the rapidity of policy changes that are occurring with respect to computer use in education, it is possible that the results are already outdated.

4. PROJECTIONS

In response to the national concern about the quality of post-secondary education, the College Board sponsored a dozen dialogues involving educators and representatives from business and industry. These groups viewed the computer as basic to an understanding of the full range of procedures that may be applied to organizing information and solving problems in diverse fields. Participants suggested that future college students will profit from preparation that reflects the broad and changing application of computer technology, including:[117]

- a basic knowledge of how computers work and of common computer terminology;
- some ability to use the computer and appropriate software for:
  - self-instruction;
  - collection and retrieval of information;
  - word processing (including the development of keyboard, composition, and editing skills);
  - modeling, simulations, and decision making; and
  - problem solving, both through the use of existing programs and through development of one's own programs;
- an awareness of when and how computers may be used in the academic disciplines and various fields of work, as well as in daily life; and
- some understanding of the problems and issues confronting individuals -- and society generally -- in the use of computers, including the social and economic effects of computers and the ethics involved in their use.

The number of computers for student use at institutions of higher education are likely to increase as rapidly as they are in elementary and secondary schools. However, some experts disagree with the prediction that within a few years, 90 percent of all colleges and universities will make computer literacy a requirement.[118] The requirement that college students be able to use computers is unlikely to be reflected in admission policies; rather it will be manifest in policies that encourage students to buy or lease microcomputers through group purchasing arrangements with hardware vendors. In two-year colleges where admission requirements are typically not as rigorous as four-year institutions, microcomputer use is likely to be encouraged through work stations and communication centers.

V. POLICY ISSUES

This final chapter addresses policy issues and strategies which face educational decision makers at Federal, state, and local levels. Building upon the findings presented in previous chapters, this discussion is based upon several fundamental assumptions: (a) that the Federal role, in place since the mid-1960s, to ensure that every child has an equal educational opportunity will continue; (b) that state education agencies will expand their pivotal roles in the area of technology use in education; (c) that the traditional roles of the states in relation to local education agencies will continue to dictate the relative levels of policy making in the different states; and (d) that governments at all levels will continue to rely, where possible, on the private sector through market mechanisms.

The policy discussion contained in this chapter is organized into five interrelated issues: (a) effective computer use in education; (b) availability of software; (c) equity and access to computers; (d) staff development; and (e) computer literacy. Each isssue focuses upon topics which are of great interest to policy makers in the education and technology communities and which are within the power of government, at some level, to influence.

Each of the policy sections which follow presents: (a) a discussion of the issue from appropriate Federal, state, and local perspectives; (b) a reiteration of relevant information from prior chapters of the report; and (c) the specification of some strategies which could be undertaken, at some governmental level, to address the issue. The strategies presented for each issue should not be considered mutually exclusive. Rather, they are a set of activities which might be undertaken, either alone or in combination with other actions, to address the issue.

A. EFFECTIVE USE OF COMPUTERS IN EDUCATION

The use of computers in education has increased dramatically over the last decade -- from several hundred in the mid-1970s to projections of more than 700,000 by the next school year and nearly three million by the end of the decade. This growth can be attributed directly to declining costs of computing power, pressures from parents on the schools, and the influence of computer-buff staff within the schools. Aggressive advertising on the part of hardware and software vendors has added to the momentum. Some experts feel that parental pressures and increased advertising will continue to influence schools to purchase more computers in the future.

The use of this equipment for computer-based learning has been proven effective, under specific conditions, for both students and teachers. A small but growing body of research findings on the effectiveness of computers in education is beginning to emerge (see Chapter III). Research generally indicates that computer-assisted instruction (CAI) has saved time and improved performance with certain student populations (e.g., disadvantaged, special education, gifted) when compared to traditional instruction and when the CAI programs are implemented concommitantly with effective teaching practices. Computer-managed instruction (CMI) programs have demonstrated cost-effective results when used by well-trained teachers. In well-implemented CAI and CMI programs, teacher and student attitudes toward subject matter and computers have become more positive. The use of the computer as a tool for word processing, spread sheet development, etc., which has increased greatly in the current school year, will continue to grow for the remainder of this decade, particularly as telecommunications advances (such as education utilities) allow students access to data bases for use in a variety of subject areas. Most experts agree that students with computer-using skills (not necessarily programming) will be more productive than their nontechnological colleagues in the information age -- now and in the future.

Most policy-making officials within school districts are interested in using computers effectively, either to increase student performance or to save time and paper work for staff. Most officials are unaware, however, of current research findings on effective computer applications and the conditions under which computer use can be expected to be effective. With few exceptions, school districts have not formulated plans for computer use nor have they invested in the staff development and institutional reform necessary to realize the potential benefits which computers offer.

State-level policy makers are becoming increasingly concerned about the effective use of computers -- especially in state-funded programs -- and are establishing mechanisms to avoid duplication of effort and waste. Moreover, the emergence of state-wide telecommunication systems will necessarily affect the educational use of computers at the local level.

Federal policy makers have heightened the consciousness of the American public and have stressed the pursuit of excellence in education. This thrust has been felt in state capitals, as well as at the community and school board levels. To the extent state and local policy makers have relied upon emerging electronic technology as a means of achieving excellence, and as schools have used funds under Federal block grant (e.g., Education Consolidation and Improvement Act Chapter II) and categorical programs (e.g., P.L. 94-142, Education Consolidation and Improvement Act Chapter I) to purchase hardware and software, both the Congress and the executive branch have a vested interest in the effective use of computers in the schools. The U. S. Department of Education (ED) has sponsored several surveys of computer use in schools, although the findings have often been limited and are frequently out of date because of the lengthy reporting process and the ever-changing uses of technology in the schools. ED has also, on a periodic basis, funded projects to provide information and technical assistance to state policy makers. Through its Special Education Programs division, the Department has also sponsored the development and/or adaptation of hardware and software for use in special education and has funded the creation of centers to provide information on courseware appropriate for special education populations and to assist software developers. Through its Center for Libraries and Education Improvement, ED has also sponsored the development of a number of comprehensive technology-based learning systems. Moreover, the National Science Foundation recently funded several software development projects which are designed to result in computer-based simulation in school science programs. Aside from a few small case studies which explore the effects and effectiveness of specific computer applications for special education populations, the Department of

Education has not funded any major research or evaluation effort which addresses the effectiveness of the use of computers in education since 1976. Federal policy makers interested in encouraging the effective use of computers in education have at their disposal no comprehensive information base. To formulate policy, they will necessarily rely heavily upon limited information and the testimony of individuals who represent vested interests.

Below we discuss several policy options for addressing the issue of effective use of computers in education, with a particular focus upon Federal and state roles.

STRATEGY: DISSEMINATE INFORMATION ON EFFECTIVE USE

The perceived need, at the school district level, for information on effective use of computers in education exists now and will grow rapidly for at least the next three years. Information needs fall into two categories: (a) empirical findings on the effects and effectiveness of computer use; and (b) information on best practices.

The U. S. Department of Education (ED) is presently spending several million dollars on studies and projects indirectly related to these research and evaluation issues. Assuming this issue is given high priority, one ED office could be given responsibility for designing and coordinating these initiatives with authority to expend appropriate funds, to ensure adequate access to research findings and data bases, and to disseminate information to users. For the most part, existing funds could be used to support such initiatives. This high-priority program of dissemination initiatives would not only provide the critical mass needed to address adequately the research issues, but would also minimize duplication of effort. Research and evaluation findings could be disseminated to state education agencies, the majority of which have offices presently in place to forward such information about technology use to local school districts. State education agencies are better equipped and staffed to disseminate research findings than to sponsor and/or conduct research on the effective use of computers in education.

STRATEGY: TARGET COMPUTER USE ON SPECIFIC POPULATIONS

A second option for Federal and state policy makers is to encourage the use of computer education with target populations, most of which receive Federal and/or state categorical or programmatic funding. These populations include special education, bilingual/Limited English Proficient (LEP), and disadvantaged students (Chapter I). Appropriate initiatives include: (a) collection and dissemination of research findings; (b) identification, documentation, and dissemination of best practices; and (c) modification of rules and regulations to encourage the use of computers with special needs populations.

To some extent, ED (through its Office of Special Education Programs) is encouraging targeted use in special education and has a limited number of studies underway which address the effects and effectiveness of computers used with specific exceptionalities. Few efforts have been undertaken at the Federal or state levels with respect to bilingual/LEP students. A small number of initiatives for disadvantaged students or compensatory education programs have been undertaken by a few states. These suggested, targeted initiatives will help to ensure equal access to technology for all students and will direct funding at student populations for which computer-based education has demonstrated some success.

This approach of targeting state and Federal action toward specific types of student populations carries some obvious, and some more subtle, shortcomings:

1. Funding would be difficult to obtain under existing appropriations and regulations. With the exception of special education, little funding is available at the Federal or state levels to support in-depth studies and evaluations of effective use or computers in specific programs and, where monies might be available at the state level, regulations do not permit funds for such purposes (e.g., administrative set-asides). Moreover, if funds were made available through other sources (e.g., Secretary's discretionary fund, individual state legislative appropriations), policy makers would be unable to coordinate initiatives effectively and the overall effort would tend to be fragmented and probably dysfunctional.

2. Staff and organizational authority for technology use would be difficult to obtain. At the Federal level, offices responsible for technology use are usually small, understaffed, underfunded, and without direct access to high-level officials. Moreover, they have evolved in various Federal offices without a coordinated plan. At the state level, the technology authority is seldom located in one of the categorical programs serving special needs populations. Few states have established technology policy task forces for state-wide planning that involve officials from special education, bilingual education, vocational education, and compensatory education branches. In states where technology coordinators exist within the various special needs programs, seldom do they have the authority and discretionary funds to implement appropriate research, development, and evaluation initiatives.

3. A review of rules and regulations affecting special needs programs must be conducted at both the Federal and state levels to ensure that local districts have the opportunity to use their computers in an appropriate manner without undue concern about future audit exceptions. Clarification of appropriate uses of computers and other technologies in special needs programs will not only minimize equity problems, but also result in greater utilization of existing hardware and software in schools generally. Those responsible for regulatory reviews should take into account both existing computer-related configurations and the changes envisioned for the future (e.g., local education utilities).

B. AVAILABILITY OF SOFTWARE

The quality and quantity of software for use in education remains a continuing policy-related issue, although the nature of the issue has changed and will continue to change throughout this decade. During the late 1970s, the availability of courseware was considered to be the major constraint to the use of computers for instructional purposes.[119] During the early 1980s, most of the commercially-available courseware was drill-and-practice used for remedial and enrichment purposes and targeted at the general education market. During this period, a number of (primarily institutional) education courseware developers and publishers redirected their efforts toward the home education market, resulting in similar packages for the two markets. For the most part, available courseware was not designed for special needs populations. Recently, many publishers and developers have again targeted on the institutional education market and have begun to develop simulation, tutorial, and other instructional packages which go far beyond simple drill-and-practice. Moreover, in response to planned textbook adoption changes in California and Texas, several major publishers recently announced the availability of "textware", in which software packages are integrated into basal text series and which include instructional management components. The 1983-84 school year saw a dramatic increase in the availability of commercial tool applications; use of such packages is expected to continue growing for the next three years, focusing primarily on the integration of data bases into instruction.

Many experts generally agree that, during the last five years, not only did the range and quantity of software increase but also the quality of courseware improved, thus expanding its potential use in a variety of subject matter areas. Indeed, most experts agree that major problems confronting school districts is now the selection of quality packages which can be easily integrated into curriculum areas.

While the quantity and, to a lesser extent, the quality of courseware has increased, corresponding increases have not occurred in such thin market areas as bilingual education/LEP programs, certain elements of special education programs, and specific disciplines within vocational education. To the extent that computer-based education is important to these special needs population students and that equal education opportunity is a national policy (see the issue below), then the availability of computer-based education in these areas is an important issue. To address the software constraints to access for special needs students, a number of policy options appear to be feasible. The options discussed below are presently being considered or (at least partially) implemented in specific areas.

STRATEGY: SUPPORT SOFTWARE DEVELOPMENT

In what have been called "thin" markets, the development of appropriate educational software has been both sparse and fragmented. The use of Federal funds to support materials, media, and software development/adaptation in special education was instituted in the 1970s. The office within the Department of Education responsible for bilingual education and programs for LEP students has begun to fund a number of pilot or demonstration projects involving computers; a recent review of these projects, however, indicated that few of them could even be evaluated because of their unclear objectives and their lack of focus on software development. Similarly, very few software development projects have been funded in vocational education at the Federal level.

Few state education agencies have funded special needs software development projects, with the exception of special education administrative packages. Only a few large urban districts (e.g., the Houston (Texas) Independent School District) have initiated major comprehensive software development efforts in such areas as bilingual education.

While some experts believe that the availablity of courseware for special education students will come close to meeting the requirements of special education teachers and students, most agree that, without some intervention strategy, a software shortfall will continue for other special needs populations. In order to meet these software needs, a comprehensive software development activity must be mounted for bilingual education/LEP programs. At the Federal level, large increases in funding would be necessary to meet the needs of the different language populations. Involvement of hardware manufacturers may be required to accommodate different type fonts and collaboration with foreign language developers may also be beneficial. Even if Federal or state funds become available, a consideraable amount of planning must be undertaken to ensure that feasible mechanisms for contract development and follow-up support (e.g., teacher training) are designed.

In vocational education, it appears that existing overall funding levels would allow continued or even expanded software development efforts, if technology were given high priority. The recently reauthorized vocational education act emphasizes the need to improve the quality of vocational education programs. Generally speaking, the software development categories which appear to be of high priority are those areas in which appropriate software -- particularly tool applications -- are not currently available (e.g., health occupations).

STRATEGY: AGGREGATE MARKETS

Another approach to the issue of software availability is based primarily upon aggregation of markets within special need categories. With or without Federal financial assistance, states and urban districts with similar needs in bilingual or vocational education would be encouraged to form consortia which would specify the types of software products they desire, thereby guaranteeing a market large enough to encourage the private sector to invest in necessary development. In certain cases, sharing of development costs between the consortia and the publishers may be required. Subsequent assistance in marketing, distribution, training, and follow-up support may also become a joint effort. Federal funds may, in some cases, be required to cover the costs of creating and administering such consortia.

This option would shift the major funding of development activities from the Federal level to the state or local level. It would decentralize the development of specifications for software packages to individual states which would, in turn, receive input from potential users at the district level. Such an approach would minimize political allegations regarding the creation of a "national curriculum". If planned correctly, this option would ensure close collaboration between the developer and the end users in both development and distribution, thus enhancing the success. If participating states or districts have low-cost telecommunications capabilities for electronic distribution of software (e.g., through state or local utilities), opportunities for access to the software would be greatly increased.

C. EQUITY AND ACCESS

Because of the lack of comprehensive information on computer use by various populations, the degree to which an equity problem currently exists is a matter of considerable conjecture. Moreover, experts generally agree that the nature of the problem will change over the next five years, becoming more qualitative than quantitative. Studies conducted primarily by individual states indicate that the ratio of computers to students in compensatory programs is equal to or, in some cases, higher than in education generally. However, the types of courseware available for these populations is usually drill-and-practice, which is qualitatively different from the more sophisticated courseware (e.g., simulation, tutorial) used to improve higher-order skills. Most experts agree that adequate access will remain a problem for LEP students and bilingual programs because of the lack of appropriate courseware. Moreover, at the secondary level, many LEP students will not have the basic skills required by computer science and computer literacy courses.

The gender equity problem has changed in recent years. During the early 1980s, male students had higher proportional enrollments in secondary and post-secondary computer-based education and computer literacy programs. Recently, however, limited studies have found increased proportions of female students in these courses. Moreover, for those females enrolled, attitude and confidence measures were not statistically different from males. A recent report by the Project on Equal Education Rights (PEER), on the other hand, found that enrollment of females in high school computer-based education programs was still proportionately lower than that of males. In instances where female enrollment increased, they were often in preparation courses for lower-paying jobs.

STRATEGY: ASSESS THE PROBLEM

Given the conflicting reports and study findings on the equity/access issue and the volatile nature of the problem, particularly with special needs populations, a comprehensive national study addressing the issue would serve to determine the existence and severity of the problem. Specifically, such a study should attempt to answer the following questions: (a) what measures should be used to assess the nature and extent of the equity/access issue?; (b) to what extent does the problem exist generally and among special needs populations?; and (c) what practices and models appear to be working best at the state and local levels to correct imbalances in access and promote equity? This study could be a separate comprehensive study or part of a large-scale data base on computer use in schools recommended earlier. Although the costs of such a study and the maintenance of a data base would be minimal, the findings would contribute considerably to a rational debate on the issue within the Congress and among Federal and state policy makers.

STRATEGY: DEVELOP TARGETED INITIATIVES

If Federal and state policy continue to provide for equal education opportunities for all students, a set of initiatives targeted at special needs populations should be considered. Some of the initiatives to be included are:

1. Federal and state regulations associated with categorical programs should be reviewed and, where necessary, modified to encourage the use of computers in programs receiving state and Federal funding.

2. Funds should be targeted to reduce or remove existing barriers:

- In bilingual/LEP programs, the major bottlenecks appear to be the lack of appropriate courseware, the high cost of distribution, and the lack of trained staff.

- For handicapped programs, the major barrier is the high cost of production and distribution, maintenance, and servicing of sophisticated communication and augmentative devices for severely handicapped students.

- For female students, a major barrier is stereotyping, which may require major leadership initiatives at the state and local levels to ameliorate tradition and entrenched perceptions on the part of school staff and the community at large.

The equity/access issue is evolutionary; some believe it is in a transition phase today and may, over time, resolve itself. Paradoxically, during the late 1960s computers were looked upon as a means to provide quality education opportunities for all students. Now, because of the availability of computers in wealthy schools and in homes of middle- and upper-income families, the limited availability of technology has become an issue itself.

D. STAFF DEVELOPMENT AND PLANNING

All experts who participated in this project agree that teacher training on effective techniques for using computers and related technology in the classroom will be critical to its long-term success in improving student performance. A second important factor is systematic planning which has occurred in only about one-quarter of the school districts which have implemented technology. In far too many instances, school districts have initially purchased microcomputers and used them in experimental modes. Only after the number of computers reaches a "critical mass" and problems surface do school policy makers realize the crucial need for staff training and systematic planning.

Most experts agree that staff development should be skill-based, addressing some of the key problems in the use of software (e.g., integration of courseware into curriculum). In-service programs, conducted by experienced computer-using school staff, should be relied upon more heavily than programs conducted by teacher training institutions. While program accreditation and teacher certification may be appropriate long-range policy instruments, most experts believe that the process of creating such instruments will be lengthy and will lack necessary flexibility, thus constraining the effective use of technology in the classroom. As industry progressively assumes a leadership role in technology-based education and training, local firms using technology in their own training programs can assist school districts in their teacher training.

The need for systematic technology planning generally exceeds the availability and commitment of resources to conduct such planning. Virtually all state departments of education and many local districts have developed planning guides, manuals, etc. which could be used by schools in planning for computer use. However, political turf battles and threatened organizational empires within districts often hamper serious planning. For school districts to implement effective planning, clearly delineated responsibilities must be defined and, in most instances, new organizational structures must be formed.

STRATEGY: EXPAND EXISTING INITIATIVES

Existing initiatives at the Federal and state levels must be strengthened and expanded. Administered by the U. S. Department of Education, the Emergency Education Security Act of 1984 is presently allocating approximately $100 million to states, institutions of higher education, and local districts to improve instruction in math and science. Several provisions of this law require that recipients use initial monies to train staff in math and science education, including the use of technology, before other formula funds can be used for hardware, software, and related materials. States are required to conduct needs assessments and, if existing teacher training needs are already met, to justify expenditures for other purposes. The National Science Foundation has received increased funding over the last two years to improve the quality of math and science instruction and to foster the development of related technology-based materials. Both of these programs should encourage local in-service training which focuses on computer-based instruction in operational settings. Federal offices responsible for consolidated and categorical programs should also encourage state and district officials to allocate larger portions of their funding toward systematic planning and staff development activities related to technology use.

Several states have undertaken initiatives focusing upon planning and training programs. Minnesota, for example, requires districts to submit plans for technology use, including staff development components, before they qualify for state software purchase subsidies. As of September 1983, Utah has mandated that all new teachers employed in the State be computer literate. Tennessee has implemented a training-of-trainers approach to implement their "Computer Skills Next" program state-wide over the next two years. Such exemplary planning and training practices should be disseminated to other states (including governor's offices and legislatures).

The private sector, including some hardware and software vendors, has supported technology training programs for state and local education staff. For example, the IBM Corporation is supporting national teacher training institutes which plans to implement 90 centers in states across the country. Tandy Corporation provides computer literacy training for teachers in their

Radio Shack computer centers. A number of local employers in cities across the country are providing teacher training and planning assistance to school districts through education industry partnership prorams.

STRATEGY: DEVELOP EXTENSIVE TRAINING PROGRAM

Most experts agree that if the new generation of microcomputer-based education is to realize its full potential, then a massive training initiative must be undertaken involving all levels of government and the private sector. Among the topics to be covered in such training are:

- The introduction of expert systems into education decision making will change fundamental staff roles, creating new positions requiring in-depth and new types of training.
- Computer-managed instruction, if implemented successfully, will require comprehensive training in principles of individualized instruction.
- The emergence of local education utilities offering a wide array of software and data base offerings will require the implementation of sophisticated training activities if these systems' potential benefits are to be realized.

Before the end of this decade, approximately 40 percent of the country's existing teacher cadre will reach retirement age. It is not clear that new financial and other incentives will be enough to attract and retain good math and science teachers in public schools. Only a massive training effort, involving the three levels of government and the private sector, which rallies the human, financial, and other resources available to public education, will begin to solve the problem.

E. COMPUTER LITERACY

Computer literacy is a rapidly changing concept defined differently by different people and interest groups. Originally conceived a decade ago as a catch-all term to include a general knowledge of the technology, computer literacy has, in recent years, become the focus of more specific and varied definitions. To this point, attempts to develop a uniform definition of computer literacy have been unsuccessful.

Most experts believe that the concept of computer literacy will change as education policy makers view the computer as one of several technology tools for the emerging information age. Some experts also believe that it would be detrimental to establish, directly or indirectly, a national definition -- or even national standards -- for computer literacy. Experts are also extremely concerned about recent attempts to include specific computer literacy items and domains on national standardized tests or other assessment tests which allow comparisons among states and among local districts within states. In the long run, national computer literacy standards and standardized testing would, experts argue, result in the propagation of obsolete standards as the nature of technology changes rapidly and new applications emerge. Given the grassroots nature of the computer-based education movement and the state and local initiatives already underway, many experts consider that such national attempts to establish standards would stifle creativity and encourage teaching of obsolete concepts.

STRATEGY: FOSTER ENLIGHTENED DEBATE

Although most experts believe a generally laissez-faire approach to computer literacy is dictated, it would be foolish to ignore the valuable contributions to technology awareness that can be made by the various parties to the computer literacy question. The only true option available to policy makers is the fostering of a comprehensive and enlightened debate on the various issues surrounding the computer literacy concept. The two critical policy questions to be addressed in this debate are:

1. Should attempts be made at the Federal level to establish standards for computer literacy, or should technology standards evolve over time through the assimilation of definitions, proficiencies, and skills identified by states and local school districts?

2. Is it desirable to have students tested for computer literacy on national standardized tests or should students be tested on performance-based skills developed by local or state education agencies?

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APPENDIX A

PROJECT METHODOLOGY

The study's design called for the gathering of research on three specific topics:

1. <u>The Use of Computers in Schools</u>: What is the basis for the growing use of computers in the education of young people, from preschool through grade 12? To what extent are computers currently in schools and to what extent are they likely to be in schools by 1990? What uses are, and will be, made of computers? What factors encourage or discourage the diffusion of computers in schools? How have different schools and school districts acquired the equipment and how are they likely to have acquired it by 1990 and 1995? Are there reallocations within budgets in order to obtain the equipment and software? For each of these questions, are there differences among schools and school districts across regions; states, urban, suburban, and rural locations; and areas with different levels of resources available for education?

2. <u>Performance and Attitudinal Effects of Computers</u>: What are the effects of computers on students' attitudes toward school and on their performance in subject areas in which computers are used? Are there reallocations of students' time among subjects? Are there differences in attitudes or perfomance among students by other demographic or educational characteristics? What are the effects of computers on the attitudes of teachers and other school staff?

3. <u>Computer Effects on Student Employment and Post-Secondary Education</u>: What are the alternative ways in which the term "computer literacy" is being used in the context of computers in education? Do employers, or are employers likely to, view "computer literacy" as a credentialling device for certain occupations or for employment generally? Do post-secondary institutions, or are post-secondary institutions likely to, view "computer literacy" as an entrance requirement for education or training programs? Does, or will, increasing the amount of computer time per student in grades K-12 reduce the amount of training time these students need to enter occupations that use computers or computer-based equipment?

Each of these three principal subjects was dealt with in a project working paper describing research findings in the area and projecting relevant trends for the future. These three working papers form the basis for Chapters II, III, and IV of this report.

Drawing upon the conclusions formed on these three topics, a fourth working paper was prepared developing a series of major policy issues which will have to be addressed if computers are to achieve their potential for improving American education. Within each policy issue were enumerated some policy options which might be entertained at Federal, state, and local levels and by the private sector. This working paper is the basis for Chapter V of this report.

In order that the project obtain a wide range of views on the subject of computers in schools, a panel of respected experts was convened for the purpose of reviewing and refining the four working papers. This panel drew its membership from many disciplines, including: universities, public school systems, state departments of education, software publishers, employers, educational technology media, and the Federal government. A listing of the individuals who participated with us in the study is included as Exhibit A-1. Each panel member brought to the project a unique perspective on the topic and offered, in some cases, strongly held opinions on items raised in the working papers. Both written and oral comments of participating experts have been incorporated into this report.

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