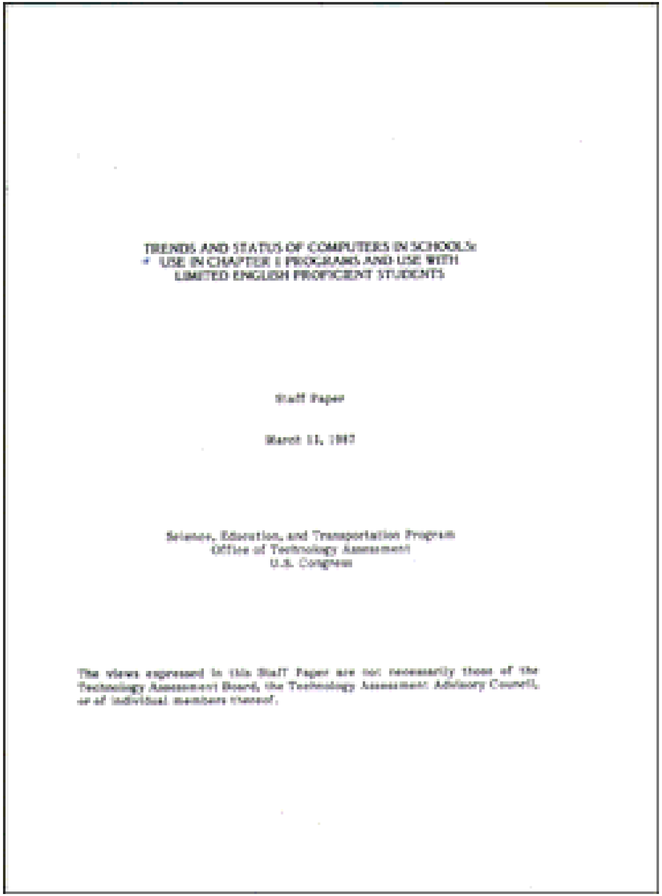
Trends and Status of Computers in Schools: Use in Chapter 1 Programs and Use With Limited English Proficient Students

March 1987

NTIS order #PB87-176723



TRENDS AND STATUS OF COMPUTERS IN SCHOOLS:
USE IN CHAPTER 1 PROGRAMS AND USE WITH
LIMITED ENGLISH PROFICIENT STUDENTS

Staff Paper

March 11, 1987

Science, Education, and Transportation Program
Office of Technology Assessment
U.S. Congress

The views expressed in this Staff Paper are not necessarily those of the Technology Assessment Board, the Technology Assessment Advisory Council, or of individual members thereof.

TRENDS AND STATUS OF COMPUTERS IN SCHOOLS: USE IN CHAPTER 1 PROGRAMS AND USE WITH LIMITED ENGLISH PROFICIENT STUDENTS

PROJECT STAFF

John Andelin, Assistant Director; OTA
Science, lnformation, and Natural Resources Division

Nancy Carson Naismith
Science, Education, and Transportation Program Director

Linda G. Roberts, Project Director

Michael Feuer, Senior Analyst

Kathleen Fulton, Analyst

James St. Lawrence, In-House Consultant

Mia Zuckerkandel, Research Assistant

Marsha Fenn, Administrative Assistant

Christopher Clary, Administrative Secretary

Michelle Haahr, Secretary

CONTRACTORS

Henry Becker
National Survey of Instructional
Uses of School Computers
Johns Hopkins University

Peter Ha
Consultant

Market Data Retrieval, Inc.

Quality Education Data, Inc.

LIST OF REVIEWERS AND OTHER CONTRIBUTORS

Jack Baptista, Massachusetts Department of Education
Henry Jay Becker, Johns Hopkins University
Bea Birman, Department of Education
Craig Blakely, SRI International
Chris Bowman, Educational Technology Consultant
Ludwig Braun, New York Institute of Technology
Dean Brown, Picodyne Corporation
Red Burns, New York University
Joanne Capper, Center for Research into Practice
Dan Daniels, Houston Independent School District
Esteban Diaz, University of California at San Diego
Kathy Dine, The Source
Patricia Dunkel, Pennsylvania State University
Norm Gold, California State Department of Education
Josue Gonzales, Chicago Public Schools
Richard Grefe, Corporation for Public Broadcasting
Bob Haven, EPIE Institute
Jeanne Hayes, QED Corp.
Ted Kahn, Picodyne Corporation
Mary Jean LeTendre, Department of Education
Alan Lesgold, University of Pittsburgh, Learning Research and Development Center
William Lobosco, Department of Education
Cecil McDermott, Project Impac, State of Arkansas
Judith McNeil, Westat Corporation
Roy Pea, New York University
Wayne Riddle, Congressional Research Service
Brian Rowan, Michigan State University
Ronald Saunders, National Clearinghouse for Bilingual Education
Karen Willets, Center for Applied Linguistics

Special thanks goes to all the State ECIA Chapter 1 Directors for taking the time to complete the OTA mail survey and telephone interview.

Special thanks also goes to our colleague, Wayne Riddle of CRS, who informed our research and analysis throughout the study.

TRENDS AND STATUS OF COMPUTERS IN SCHOOLS:
USE IN CHAPTER 1 PROGRAMS AND USE WITH
LIMITED ENGLISH PROFICIENT STUDENTS

TABLE OF CONTENTS

SUMMARY

TRENDS AND STATUS OF COMPUTERS IN SCHOOLS: USE IN CHAPTER 1 PROGRAMS AND THOSE FOR STUDENTS WITH LIMITED ENGLISH PROFICIENCY

SUMMARY

INTRODUCTION

Computer use in schools mirrors the heterogeneity of the American public education system. Hardware and software span a wide range of products, the organization of these resources varies among schools, and the technology is used in many ways. Some teachers have found effective ways to use a single computer with a classroom of students, while others prefer a concentration of resources. There are also rare examples, in experimental settings, of classrooms equipped with a computer on each child's desk as well as a computer for each child's home. Some schools have concentrated their technological resources in computer centers or labs, while others have one or more computers in various classrooms located in several areas of the school campus, often including the library or media center. One reason for the wide diversity of approaches is the fact that the original focus on computer literacy, and on teaching students programming has shifted: the one dominant theme in the evolving and growing use of technology in schools is that the computer is now seen as a tool for learning that can be integrated into all areas of the curriculum.

DISTRIBUTION OF EQUIPMENT

Between 1981 and 1986, the percentage of American schools with computers intended for instruction grew from about 18 percent to almost 96 percent. There are now more than one million computers in public schools alone, and over 15 million students and 500,000 teachers in public and private schools who make use of computers (stand-alone microcomputers) and related technologies. The national pattern is a widespread distribution of the technology to as many schools as possible, rather than a concentration of specific hardware and software to user groups with particular needs. This pattern of broad diffusion reflects the efforts of parents, teachers, and school systems nationwide. OTA'S analysis shows three striking, recent changes in characteristics of computer use in education:

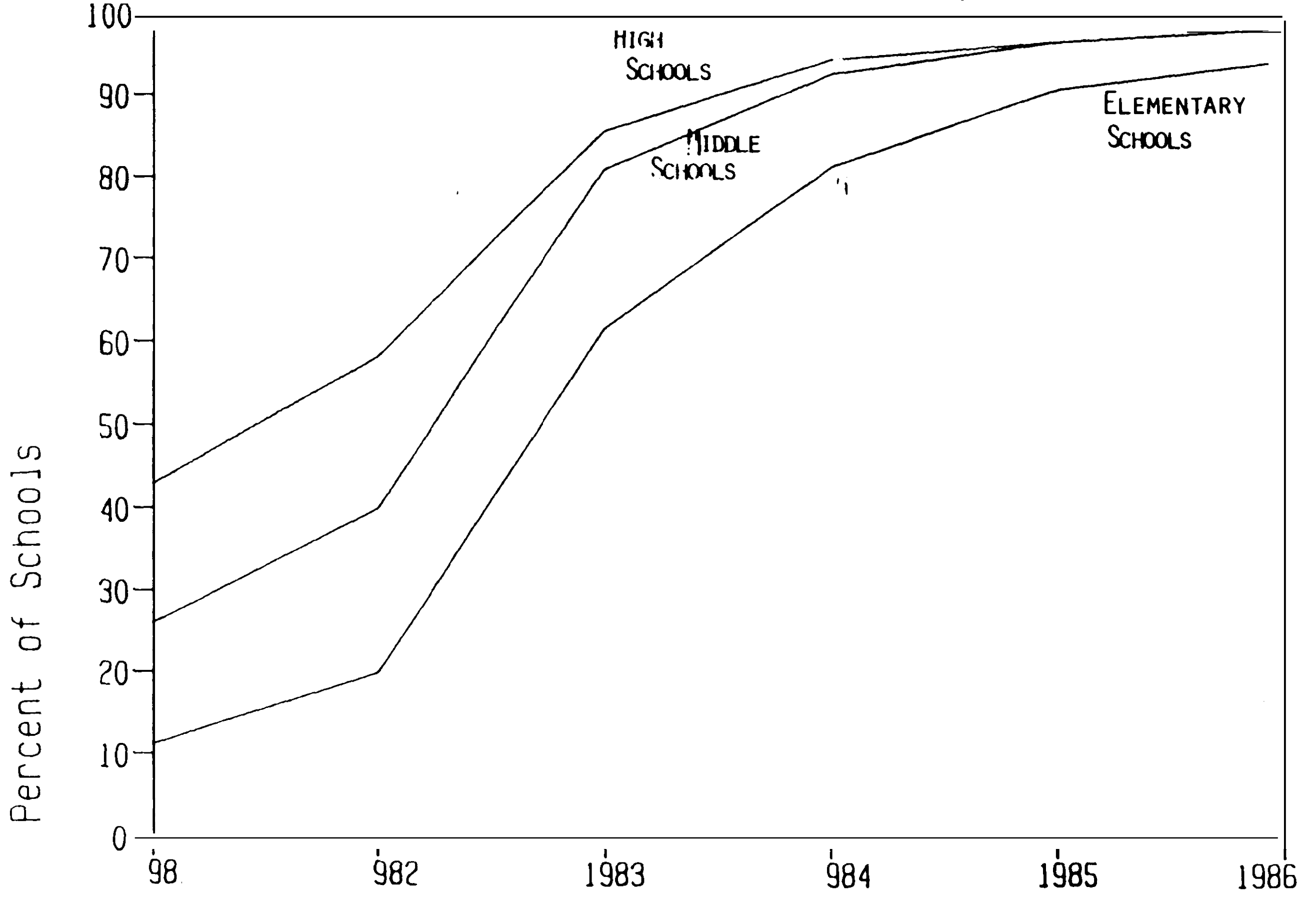
- Elementary schools are catching up in computer use to the early lead of secondary schools that existed at the beginning of the decade. In the 1986-87 school year, almost 95 percent of all public elementary schools had computers, as did almost 99 percent of all public middle and secondary schools. Private schools are still running behind, with only about 77 percent using computers for instruction. [See Figure 1]

- Pupil access to computers has also improved with increasing investments in the technology by schools. Today, the national average is about 37 students per computer, which means that statistically there is still less than the equivalent of one computer per classroom. There are significant variations in this measure of access by region [See Figure 2] and school size [See Figure 3], and by student characteristics.

- Applications of computers in school vary. Some regions of the country continue to focus on computer literacy and programming at different grade levels. [See Figure 4] At the same time, there is a growing emphasis on integrating the computer into the curriculum.

FIGURE

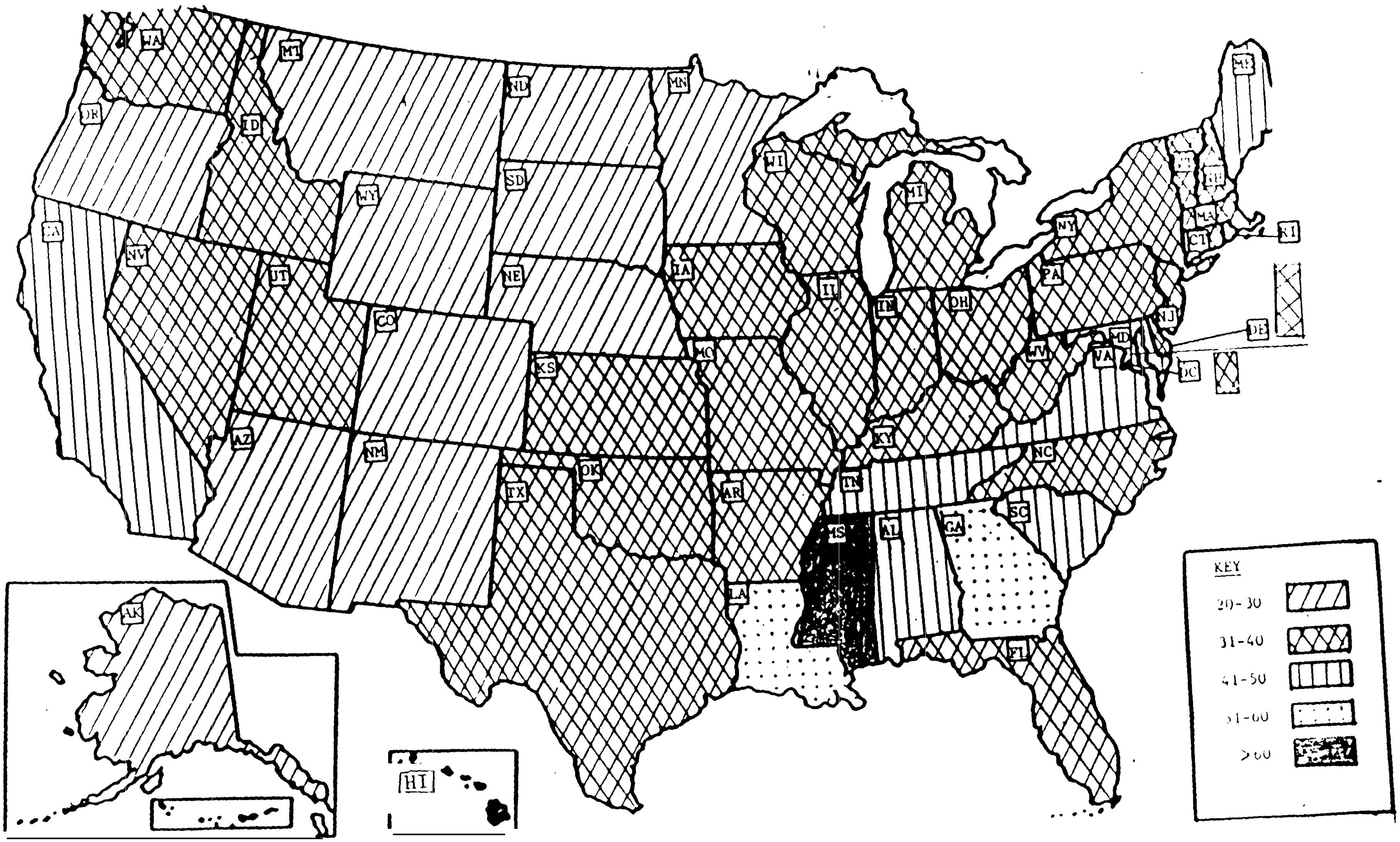
Percent of Public Schools with Computers, 1981–1986



SOURCE: Market Data Retrieval, Inc., Westport, CT, 1986.

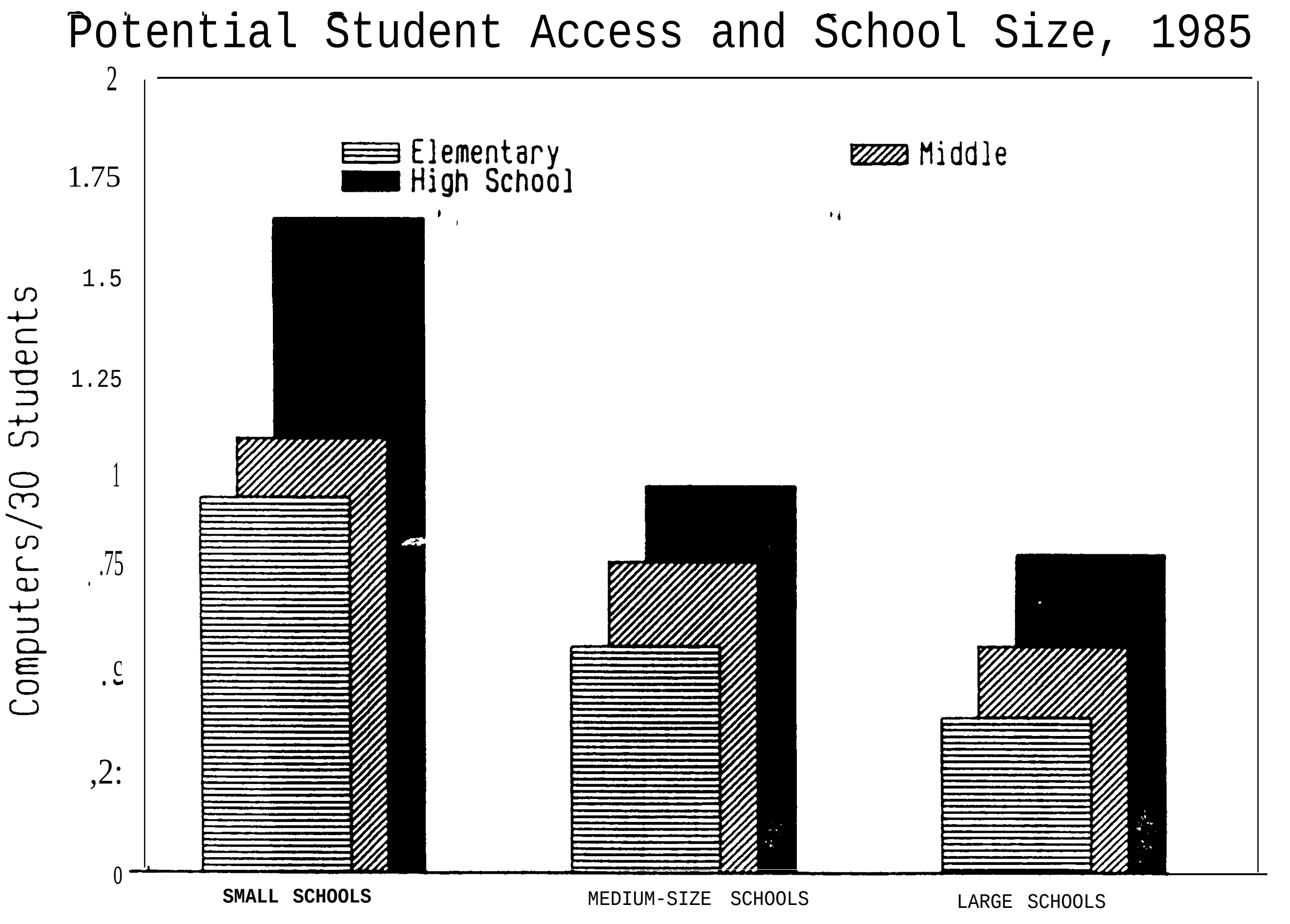
FIGURE 2

CROSS-STATE DIFFERENCES IN AVERAGE NUMBER OF STUDENTS PER COMPUTER, 1986



SOURCE: OTA

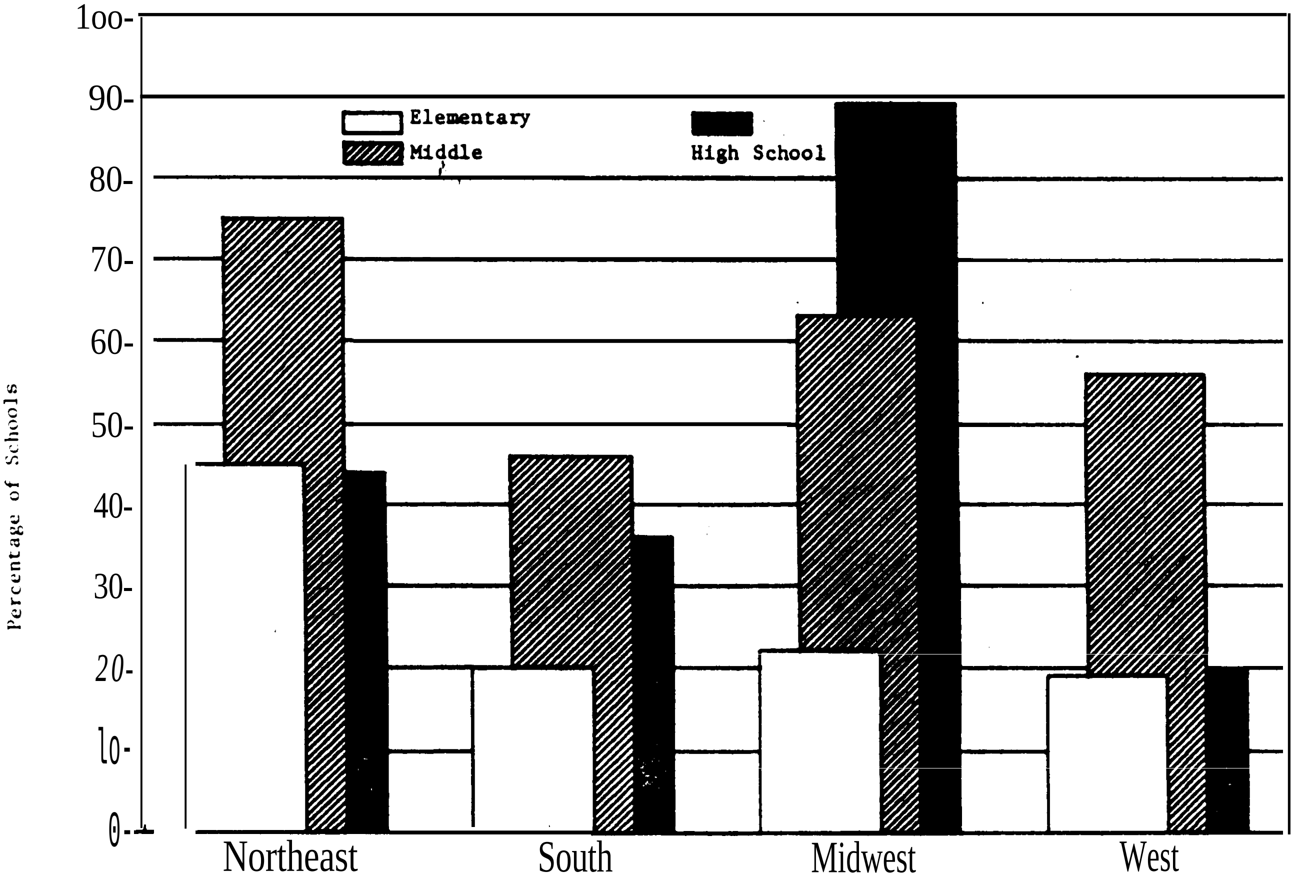
FIGURE 3



SOURCE: 1985 National Survey of Instructional **Uses** of School Computers, Center for the Social Organization of Schools, Johns **Hopkins** University.

NOTE: Small, medium, and **large** size categories are specific to grade span of school.

FIGURE 4
REGIONAL VARIATIONS IN COURSE REQUIREMENTS*



*Semester-long courses in computer literacy or Programming.

SOURCE: 1985 National Survey of Instruction Uses of School Computers, Center for the Social Organization of Schools, John Hopkins University.

EQUITY AND ACCESS

Despite the widespread diffusion of computers in the Nation's schools, there has been a persistent-concern with equity of access, particularly in terms of possible differences between the rich and poor, black and white, and boys and girls. In the early part of the decade, unequal access was inevitable: computers were coming into the homes of those who could afford them, and into schools located in communities with ties to the microelectronics industry and/or where parents were actively involved in acquiring the technology for schools. While OTA finds that — in terms of the number of schools with computers and the number of students per computer — the gap between rich and poor has been narrowing, important differences still exist:

- Generally, students in relatively ‘poor" elementary or middle schools have significantly less potential access than their peers in relatively "rich" schools. At the high school level, however this trend disappears. [See Figure 5]

- Differences between access for rich and poor students vary across the 50 States and the District of Columbia.

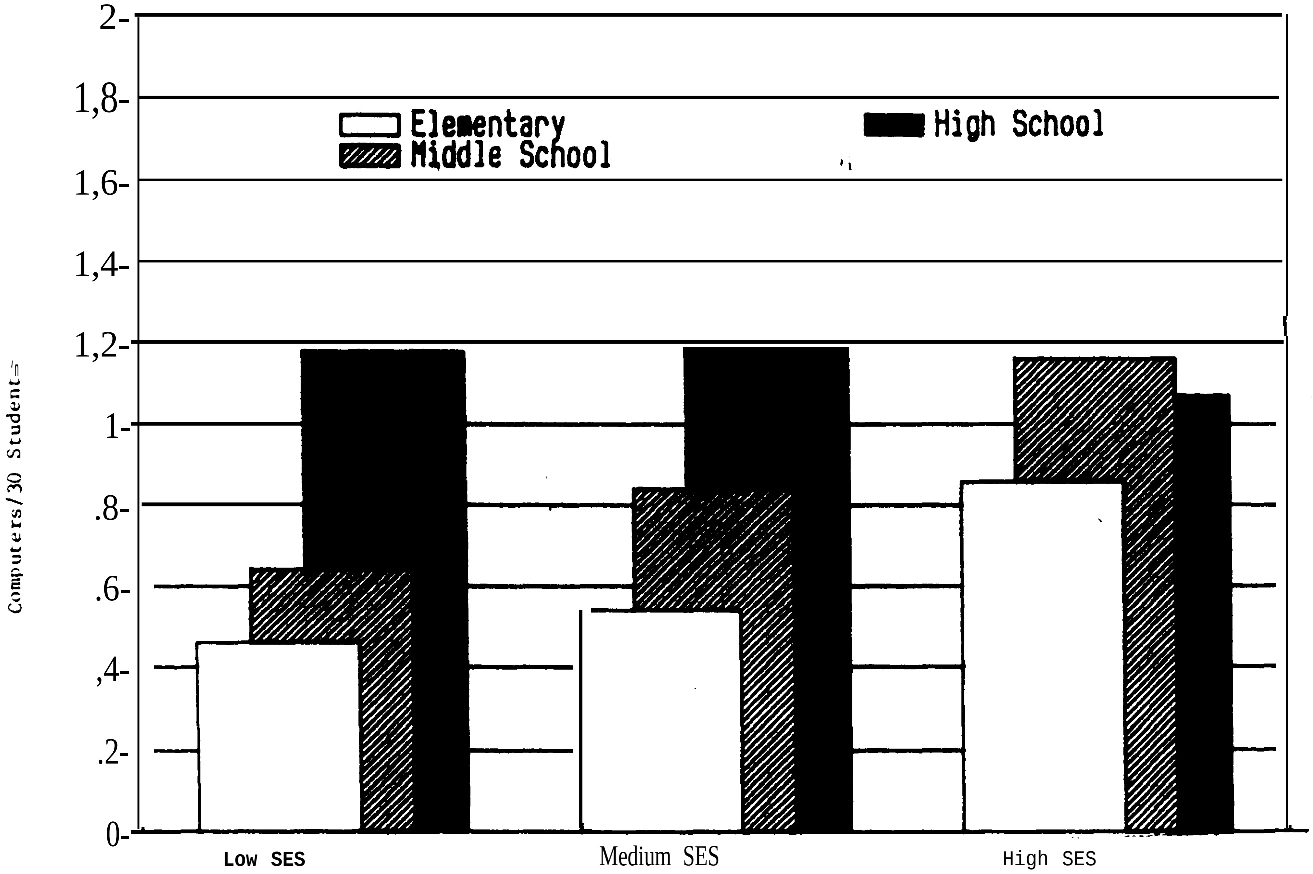
Differences in the number of schools with computers also exist between black and white students:

- In 1985, black children were less likely than white children to attend elementary schools with computers. [See Figure 6] However, since today almost all schools have computers, these differences found in 1985 are narrowing.

- Pupil access varies with the percentage of black students in the school.

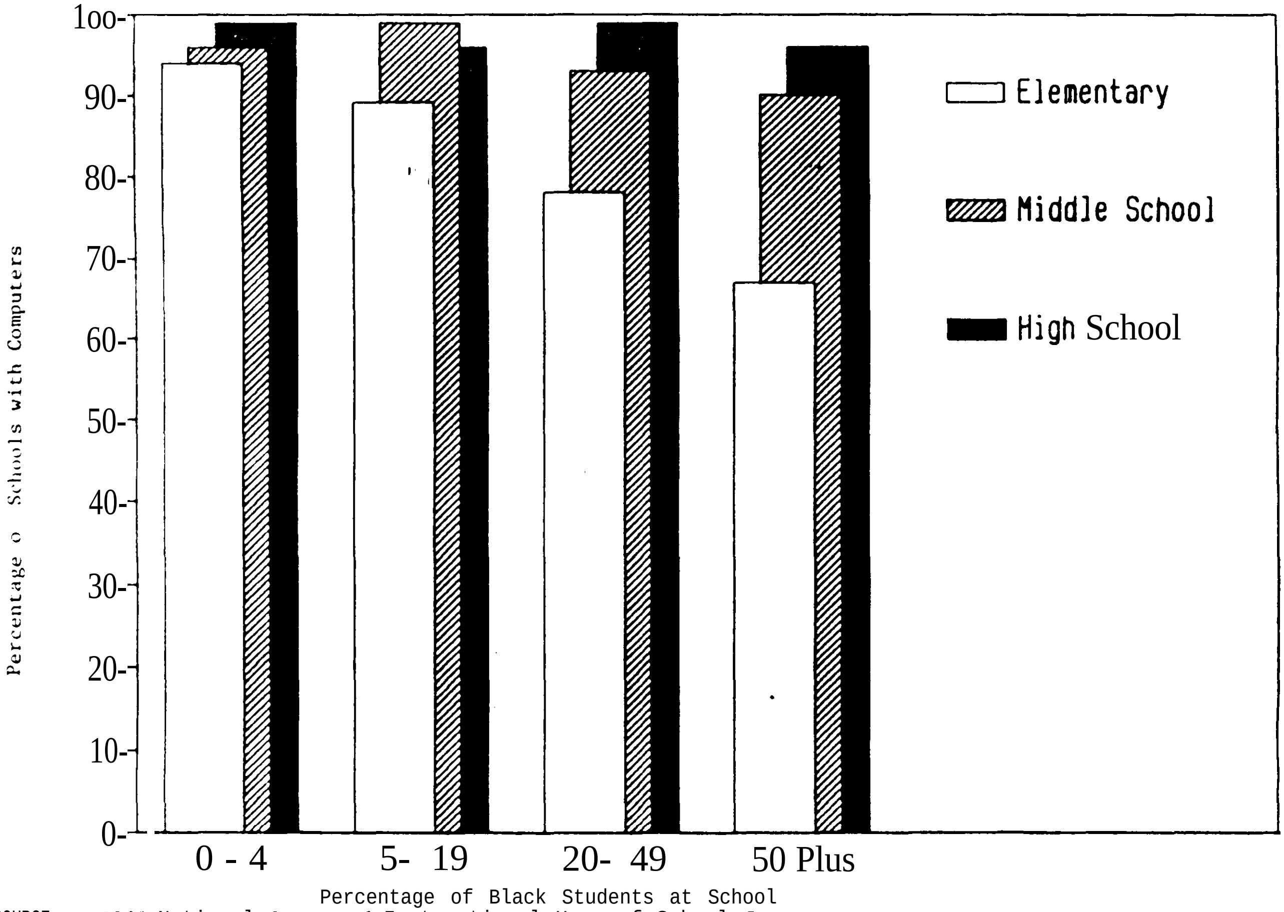
FIGURE 5

SOCIOECONOMIC STATUS* AND ACCESS (1985)



*SES measure based on school-wide index of parents' occupations and incomes

SOURCE: 198S National Survey of Instructional Uses of School Computers, Center for the Social Organization of Schools, Johns Hopkins University.



SOURCE : 1985 National Survey of Instructional Uses of School Computers, Center for the Social Organization of Schools, Johns Hopkins University.

[See Figure 7] However, this effect can be explained in part by the fact that black children typically attend relatively large schools, in which pupil access to computers — for all students in the school — is lower than in relatively small schools.

In some respects, boys and girls use computers about equally, especially when computers are tied formally to curricula:

- Boys and girls are about equally enrolled in elective computer programming classes in middle and high schools, and in high school programming courses with algebra or advanced mathematics prerequisites.

- There is no apparent gender difference among students in overall use of computers or in word processing during the regular school day.

- Boys tend to dominate computer use during non-school hours (before and after the regular school day).

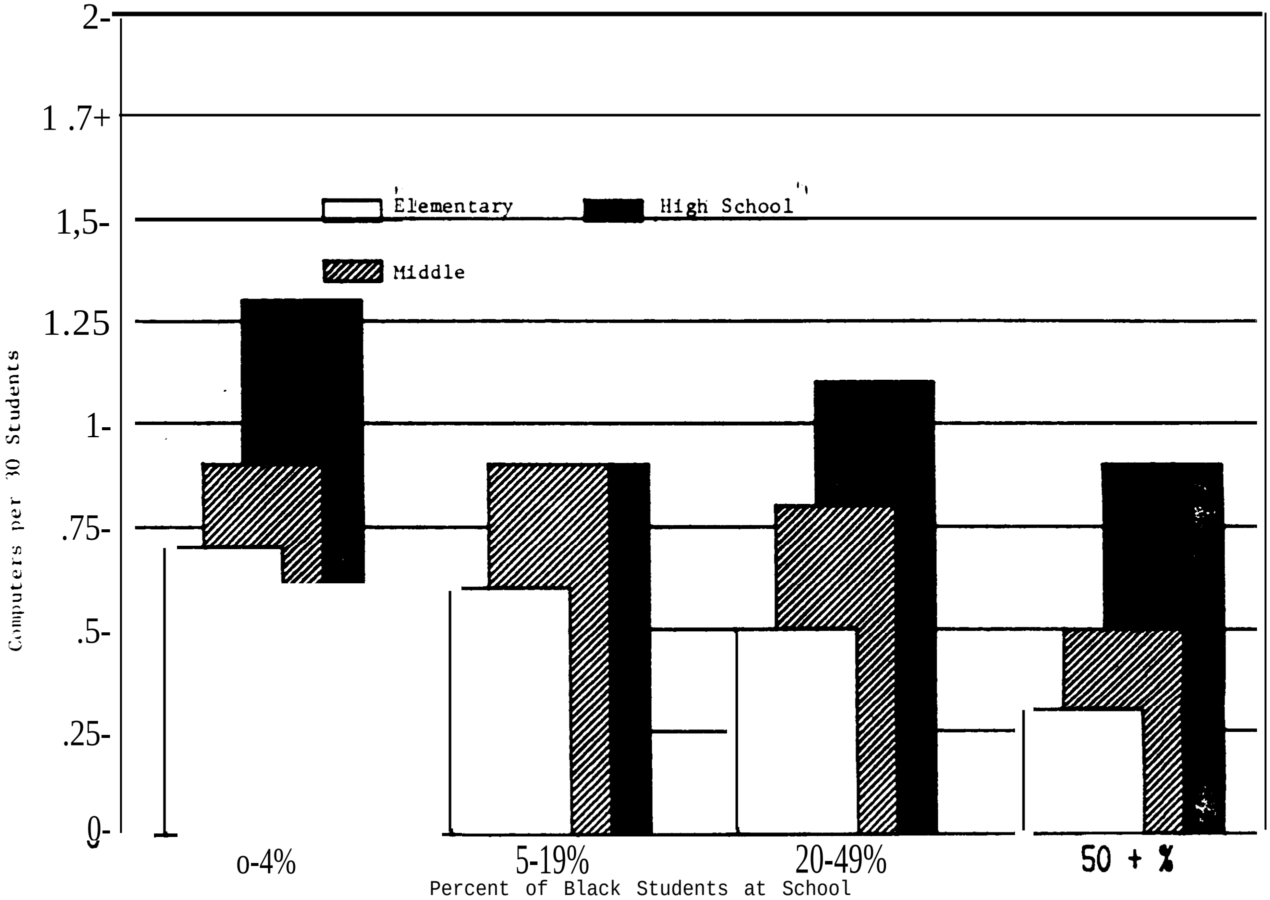
- In some schools, boys dominated all types of computer use, while in very few schools, girls infrequently dominated any type of activity, except for high school word processing.

INSTRUCTIONAL APPLICATIONS

Typically, students who were using computers a decade ago were learning to program them. If not programming, they were learning "about the computer," and only to a limited extent were they using it directly in subject matter areas. This emphasis on

FIGURE 7

PUPIL ACCESS BY PERCENT OF BLACK STUDENTS AT SCHOOL



SOURCE: 1985 National Survey of Instructional Uses of School Computers, Center for the Social Organization of Schools, Johns Hopkins University.

programming was expected, as most early teacher advocates were computer aficionados, and also because very little educational software was available. Patterns of use changed with the advent of more powerful hardware, varied content-related software, child-oriented programming languages such as LOGO, and generic software tools, as well as broader involvement of the teaching staff. By 1985, student instructional time on computers overall was divided almost evenly between drill and practice, programming, and all other uses, including problem solving and word processing. OTA finds, however, that there are important differences in use by schools of different grade spans and between schools with many low achieving students and schools with many high achieving students:

- Elementary school students spend most of their computer time on drill and practice; middle and high school students spend more time on programming and word processing. [see Figure 8]

- Low-achieving students use computers to practice and reinforce basic skills while high-achieving students concentrate more on programming and problem solving. [See Figure 9]

- Students in poorer (low socioeconomic status) schools typically spend more time with drill and practice than students in richer (high socioeconomic status) schools. [See Figure 10]

Computer Use in Chapter 1 Programs*

In every State, Chapter 1 programs funded the purchase and/or lease of computer hardware and software.[1] While not all Chapter l programs use computers, 58 percent of

---

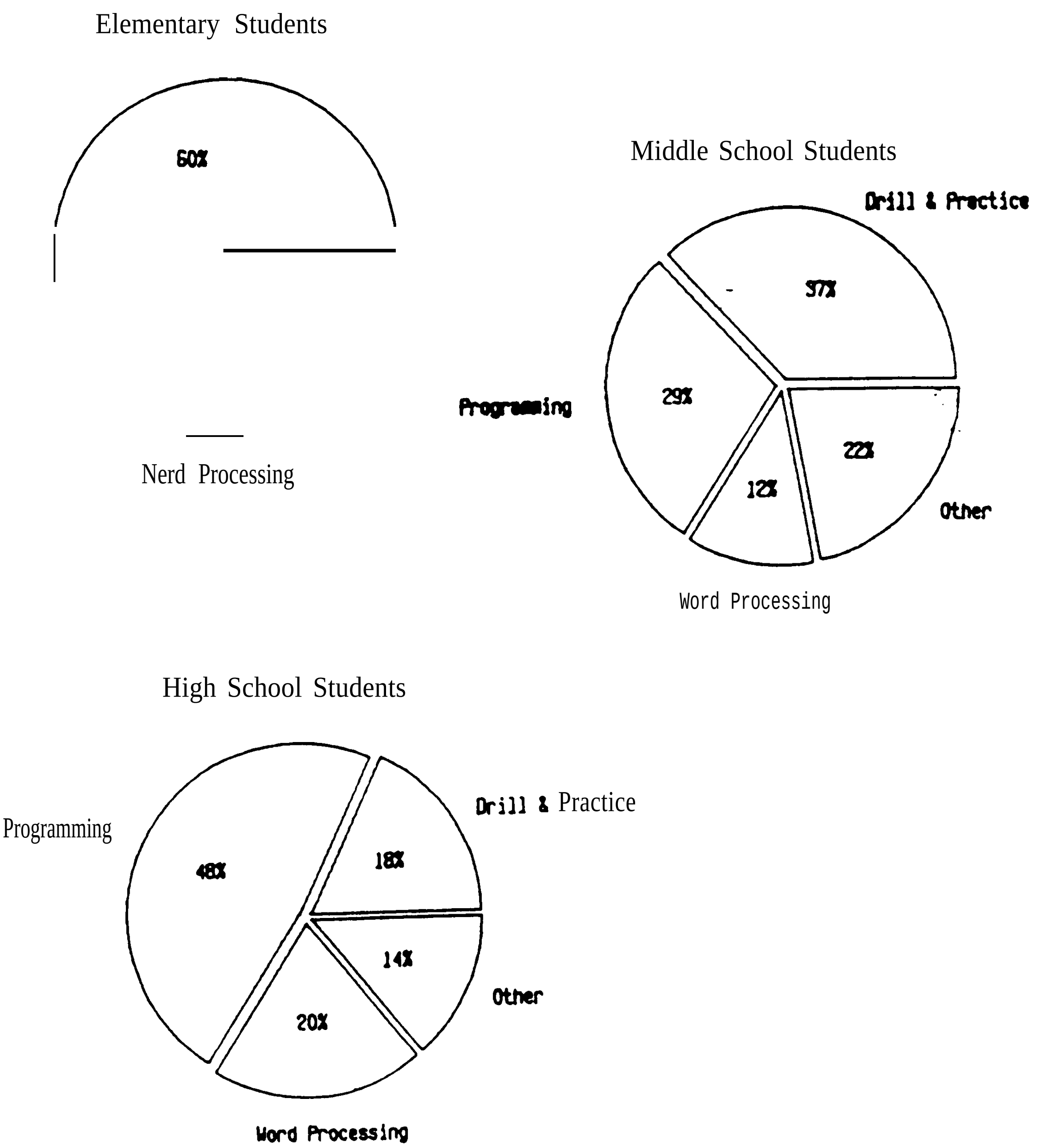
* Chapter 1 of the Education Consolidation Improvement Act (ECIA) provides compensatory educational and related services to educationally disadvantaged students who attend schools in low-income areas.

FIGURE 8

INSTRUCTIONAL APPLICATIONS OF

COMPUTERS:

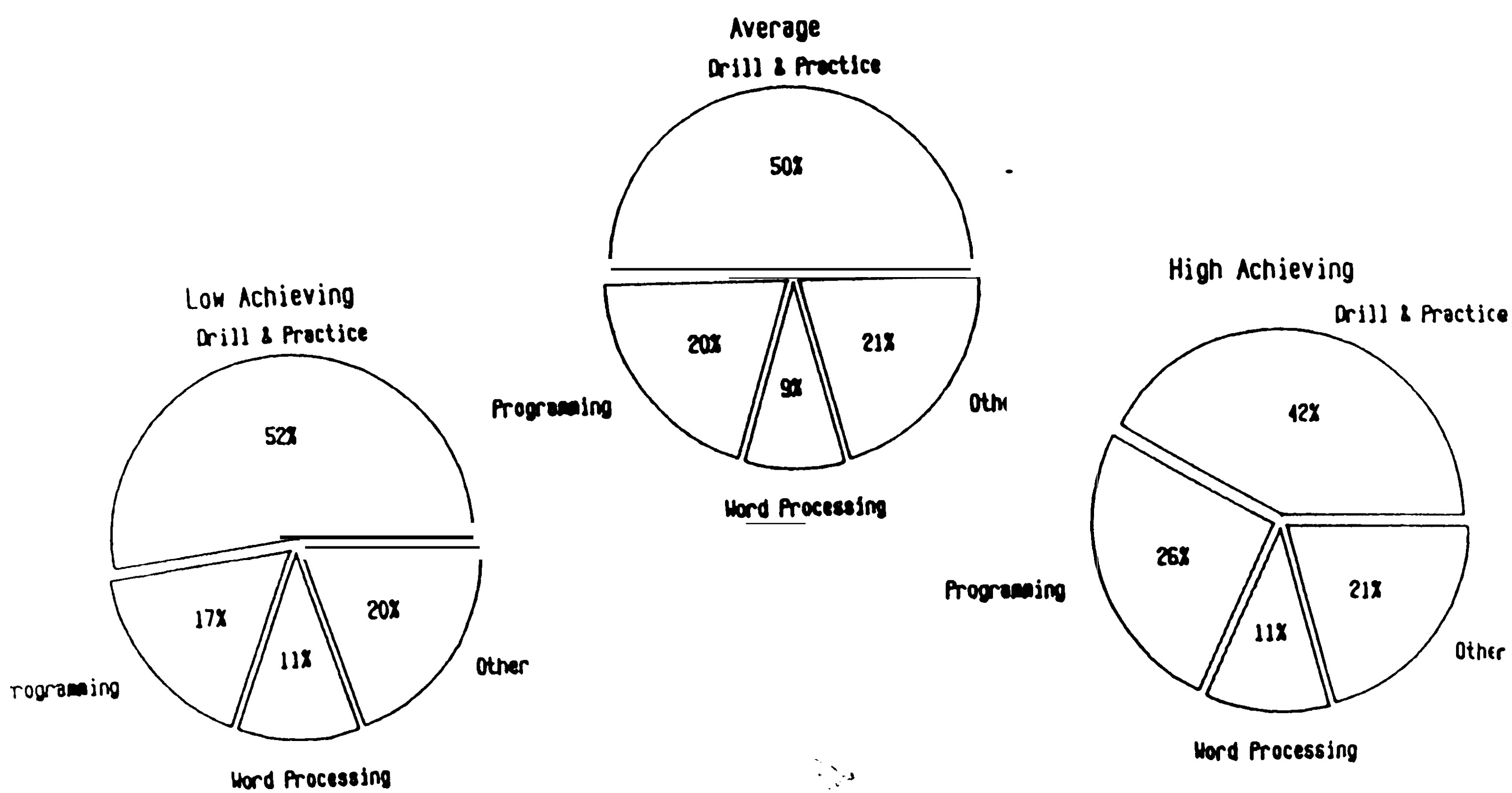
VARIATIONS BY GRADE SPAN OF SCHOOL



SOURCE: 1985 National Survey of Instructional Uses of School Computers, Center for the Social Organization of Schools, Johns Hopkins University.

FIGURE 9

INSTRUCTIONAL APPL CATIONS OF COMPUTERS: VARIATIONS BY ACHIEVEMENT LEVEL*

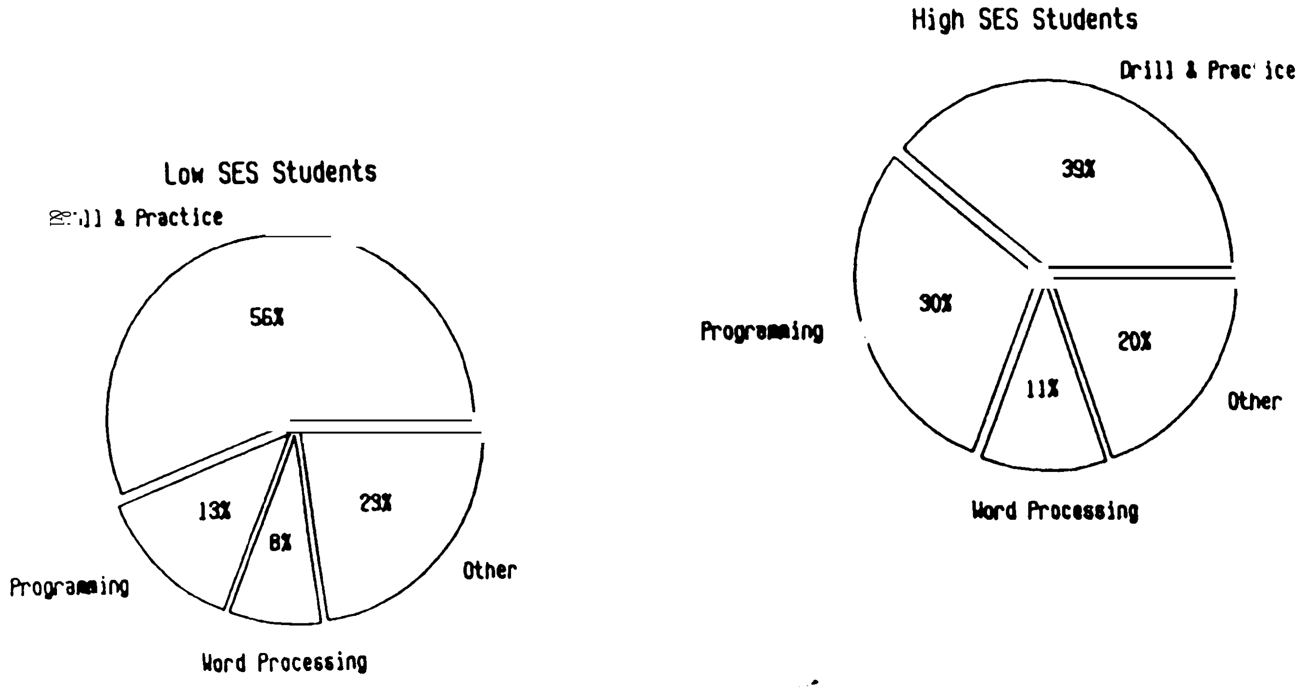


* SCHOOL-WIDE ABIL TY MEASURE

URCE: 985 Na ional Survey of Instructional Uses of School Computers, Center for the Social Organization of Schools, Johns Hopkins University.

FIGURE ⊙

INSTRUCTIONAL APPLICATIONS OF COMPUTERS: VARIATIONS BY SOC OECONOMIC STATUS OF STUDENT



SOURCE: 985 Nationa Survey of Instructiona Uses of School Computers, Center the Social Organ zation of Schoo
Johns Hopkins University.

Chapter 1 public elementary school teachers and 60 percent of public Chapter 1 middle/high school teachers use computers to teach their students. Of the over 3 million Chapter 1 elementary school students nationwide, about 2.4 million (71.6 percent) have Chapter 1 teachers who use computers. Of approximately 960,000 Chapter 1 middle/high school students nationwide, 540,000 (56.1 percent) have Chapter 1 teachers who use computers. [See Figure 11] These aggregate statistics should not obscure important details:

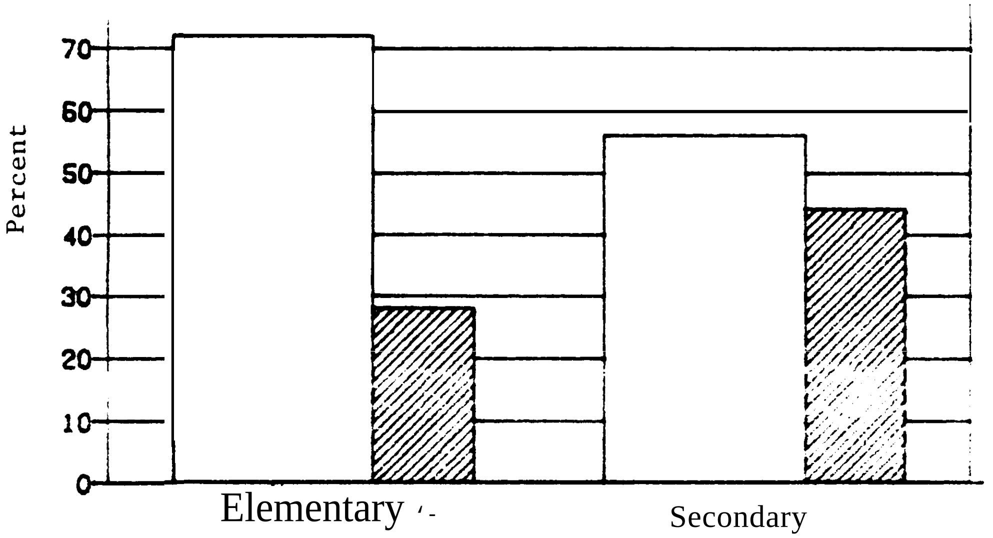
- Chapter I teachers working in high schools where more than 40 percentof the students are eligible for free lunch are less likely to use computers than teachers working in other high schools.

- Except for the poorest schools, the use of computers by Chapter 1 teachers in elementary schools <u>increases</u> with the school% concentration of poor students; in the very poorest elementary schools — where more than 75 percent of the students are eligible for free lunch — the percentage of Chapter 1 teachers using computers is <u>lower</u> than in any other schools. [See Figure 12]

- There appears to be a slightly higher proportion of low-ability students in the classrooms of Chapter 1 teachers who use computers than in classrooms where Chapter 1 teachers do not use computers. [See Figure 13]

The principal use of computers in Chapter 1 programs is for drill and practice for basic skills with every State reporting such use. Many States also report that computers are being used in these programs for problem solving and for exploring other approaches, including using the technology to teach higher order thinking skills, or to teach computer

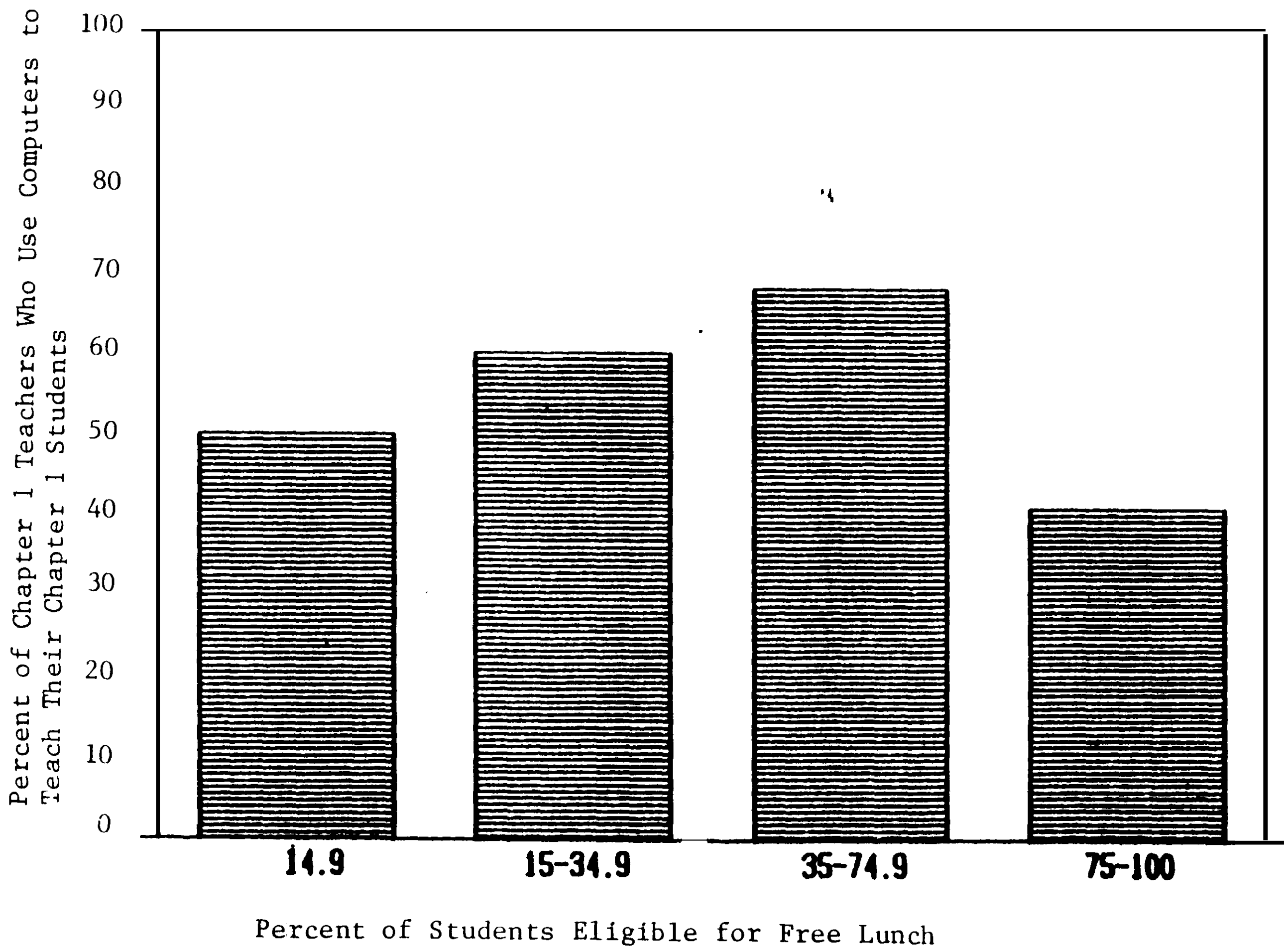
1. OTA estimates that this has amounted to more than $89 million since 1980. Moreover, approximately $21 million is expected to be spent in the 1986 to 1987 school year. OTA, "Survey of State Chapter 1 Coordinators," October 1986.



SOURCE: Westat Corporation, National Survey of ECIA Chapter 1 Schools, 1986.

FIGURE 4

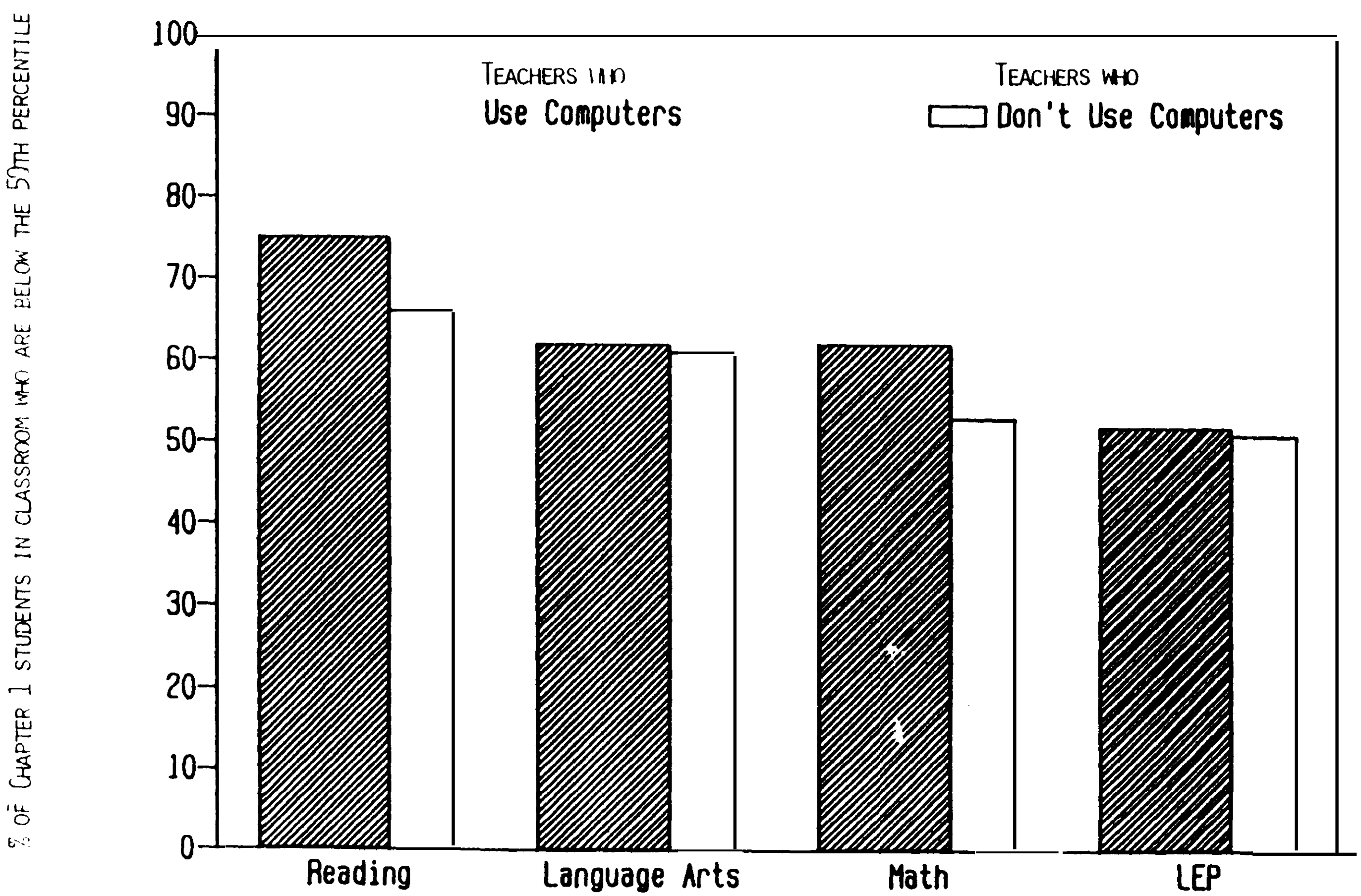
CHAPTER 1: COMPUTER USE AND ELEMENTARY SCHOOL POVERTY LEVEL



SOURCE: Westat Corporation, National Survey of ECIA Chapter 1 Schools, 1986

FIGURE 13

COMPUTER USE BY CHAPTER 1 TEACHERS: VARIATIONS BY ABILITY LEVEL OF CHAPTER 1 STUDENTS IN THEIR CLASSES



SOURCE: TAT CORPORAT NAT SURVEY ECIA CHAP SCHOOLS, 1986 literacy skills.

Given the Chapter 1 emphasis on remediation of basic skills and instruction geared to meet individual needs, and the wide availability of software in reading, mathematics, and language arts, the use of computer technology in Chapter 1 has clearly been appropriate. In addition, Federal funds made it possible to take advantage of comprehensive and costly computer-assisted instruction (CAI) systems that were originally developed for disadvantaged learners.

Computer Use in Programs for Limited English Proficient Students

With respect to bilingual and English as a second language (ESL) education, (programs designed for limited English proficient students), there are important differences in computer use between Chapter 1 and regular classrooms [see figure 14]:

- Among Chapter 1 teachers who teach ESL (and possibly other subjects), 40 percent use computers. Among Chapter 1 teachers who teach ESL only, just 24 percent use computers. These two figures are consistently lower than the proportion of other Chapter 1 teachers who use computers.

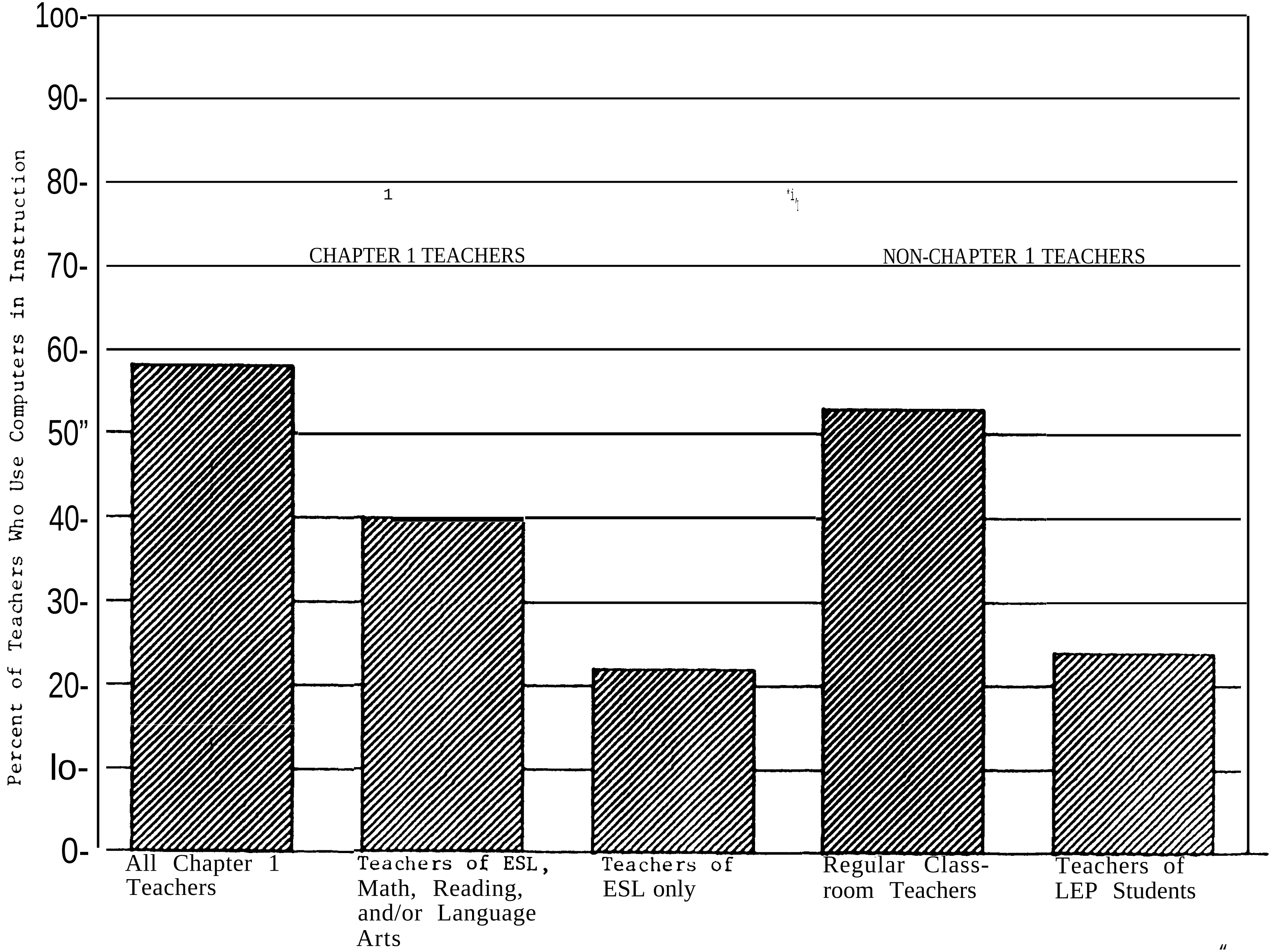
- Among regular classroom teachers who teach limited English proficient (LEP) students, 22 percent use computers. This is" even lower compared to the proportion of all regular classroom teachers (50 percent) who use computers.

Data suggest, too, that LEP students are more likely to use computers if they receive Chapter 1 services. However, OTA identified several Title VII projects, * local district efforts, and university-sponsored projects that employ computer resources to increase students' English language skills. A Title VII project in District 1 of the Seattle Public

---

* The Bilingual Education Act, Title VII of the amended Elementary and Secondary Education Act of 1965, provides educational services for school-age limited English proficient (LEP) students to help them learn the English language well enough to fully function in all-English classes.

FIGURE 14. -TE`ACHERS* USING COMPUTERS IN INSTRUCTION



*In schools receiving Chapter 1, State, or other compensatory education, or special education services.

SOURCE: Westat Corp., National Survey of ECIA Chapter 1 Schools, 1986

Schools developed their own CAI for Vietnamese, Cambodian, and Laotian high school students.** In San Diego, Spanish-speaking students use computers after school to develop English literacy and computer expertise in a model program developed by university researchers.

EFFECTIVENESS

As computer use expands in schools, generally, and in Chapter 1 programs, questions are inevitably raised regarding benefits and costs. The issue of overall cost effectiveness of computer technology remains unsolved. This reflects the difficulties of comparing the technology to other irstructional choices, problems associated with fully identifying costs, and the complexities of defining and measuring the full range of effectiveness criteria. However, leaving aside the question of cost, there is considerable agreement that computers are effective.

Research and national reports on computers in education convey a common theme of positive effectiveness, with the caveat that current practice can be improved. More than two decades of research on computer-assisted instruction (CAI) show that students make learning gains, as measured by test scores, when they use programs that are primarily drill and practice. The particular benefits of CAI for disadvantaged youngsters have been well documented in the research literature.

Additional data on effectiveness come from local district evaluation studies of Chapter 1 computer use. These studies document significant achievement gains in mathematics and reading through computer drill and practice, in comparison to "regular" Chapter 1 instruction. Lack of standardized data among various programs make it

---

** The software itself is bilingual, with text and instructions generally in English, and vocabulary in English and the native language. Native language instruction is utilized to explain the operation of hardware and software, clarify vocabulary, facts and concepts, and link this knowledge with students' conceptual framework of native language, culture, and history.

difficult to compare results among various approaches. Furthermore, none of the Chapter 1 program evaluations compared the benefits of drill and practice with other types of computer based instruction, such as use of simulation or problem solving approaches, or to other nontraditional approaches. Future research might consider these issues.

In response to an OTA survey of State Chapter 1 coordinators, one message came through strongly: the coordinators emphasize that the computers an effective learning tool but that the teacher is not replaced. The teacher plays an essential role throughout.

Research studies on uses of technology with LEP students are not extensive; few studies have been conducted and more are needed. Several projects exploring use of computers with LEP students show promising results: for these students, word processing and computer networking provide vehicles for students to function effectively in both their native language and in English.

With both Chapter 1 and LEP students, there is a considerable overlap of needs created by poverty. OTA finds that there is a general belief among researchers and practitioners that computer technology enhances motivation for learning, because it can be nonjudgmental, it provides immediate feedback, it allows students to work at their own pace, and it helps raise students' "status" in their schools.

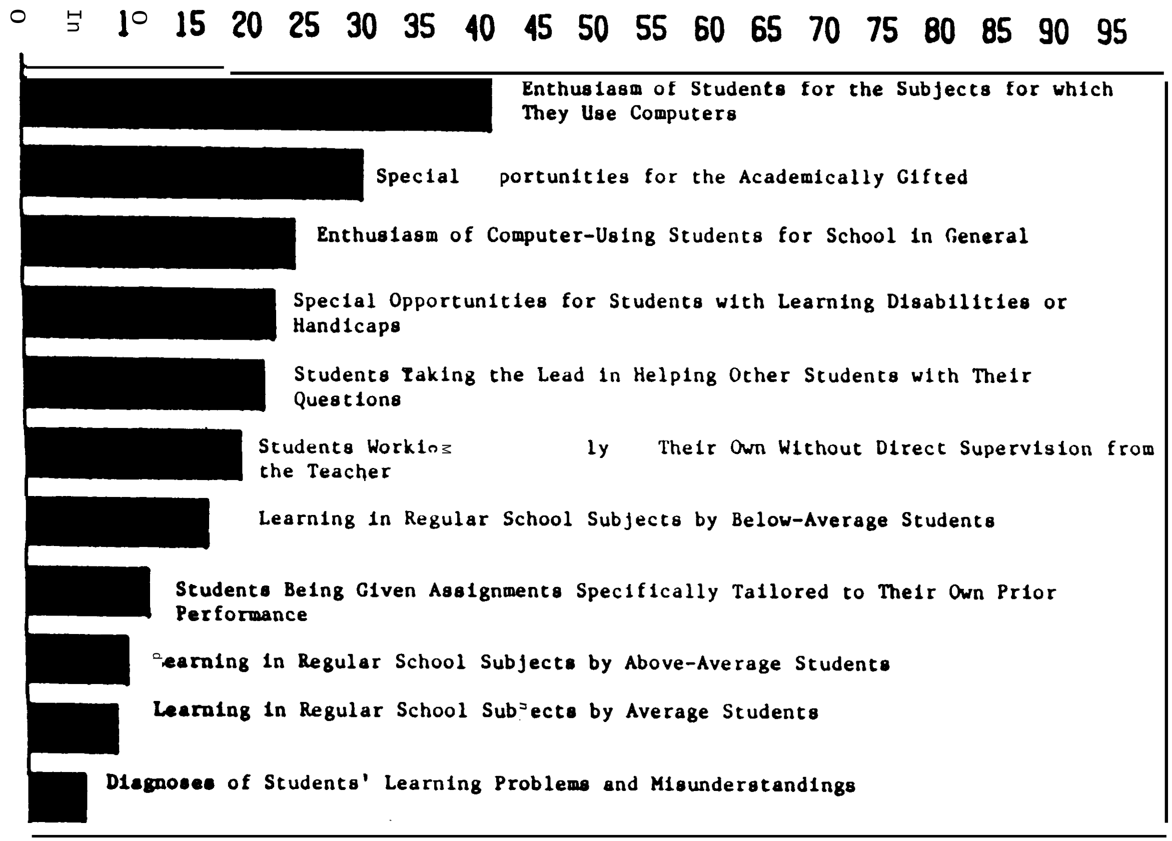
Research on the use of computers to develop higher order thinking skills has not yet produced definitive results. Some work with Chapter 1 students looks promising. In general, research on the impacts of learning to program a computer has not been able to show that there are significant gains in problem solving skills or that this learning transfers to other subjects.

Survey data on teachers' and principals' perceptions of the effects of computers provide additional insights [See Figure 15]:

- Computer use is perceived by many teachers to raise students' enthusiasm for subjects in which computers are used.

FIGURE ≡

Perceived Effects of Computers



Percentage of primary computer-using teachers who reported that "as a result of computers, this is MUCH IMPROVED at our school" (Respondents could have chosen "somewhat improved" or "little changed" or "negatively affected")
SOURCE: 1985 National Survey of Instructional Uses of School Computers, Center for Social Organization of Schoo Johns Hopkins University.

- Many teachers report that computers offered new and challenging activities to academically gifted students who might otherwise have been restricted to conventional curriculum materials.

- The number of teachers who perceived that computers helped below-average students learn regular schools subjects was higher than the number of teachers who perceived that computers helped average or above-average students.

ADMINISTRATIVE USES

In Chapter 1 programs, OTA found that the computer is becoming an essential administrative tool in the instructional process: for example, tracking student progress, keeping records, preparing reports, and other tasks. There is promising evidence that these administrative tools increase the productivity of the Chapter 1 program by allowing teachers to spend more time with students. Another improvement mentioned is an increase in the ability to coordinate Chapter 1 student activities with regular classroom objectives.

There is another area, however, where questions are being raised. Given the considerable investment in hardware and software, a number of Chapter 1 program managers and other school administrators would like to find a way to make better use of the technology. Under Chapter 1 regulations, equipment purchased with Chapter 1 funds can only be used to benefit Chapter 1 students. The result is that equipment stands idle when Chapter 1 classes are not scheduled. If there were ways to use these technology resources more fully, greater benefit could be made of the investment. The flexibility of the technology, the fact that the hardware can be used for many hours a day, and the cost of the instruction all support an approach of maximizing use of the equipment rather than limiting it. This is an area where further guidance regarding Federal requirements appears to be needed.

Some Chapter l programs are experimenting with using computers on a shared basis with other programs. In these other programs, e.g., regular classroom, parenting program, or after school enrichment, one approach is to purchase technology with general funds and avoid problems of restricted use. Another suggestion is to allow schools to prorate costs for use between Chapter 1 and other programs, so that other students or special programs can also use hardware and software.

THE SPECIAL CASE OF AGUILAR v. FELTON

By law, local Education Agencies (LEAs) are required to serve eligible Chapter 1 students who attend private schools. On July 1, 1985, the Supreme Court, in the case of Aguilar v. Felton, ruled unconstitutional a common method of providing Chapter 1 services to eligible children who attend nonpublic sectarian schools. According to the decision, the provision of instruction by public school teachers traveling to those schools led to excessive and unacceptable entanglement of Church and State.[2] Thus LEAS are trying to sort out the options that come out of a mandate to provide services to these students and a prohibition on the way these services were provided. There area number of ways to solve the problem. One solution is to deliver instruction to students via the computer.

Thus some LEAs are making investments in technology to provide services to Chapter 1 students in nonpublic sectarian schools. In some configurations, the LEA

2. Aguilarv. Felton, 105 S.Ct. 3232.

maintains and operates a mainframe or host computer on a public school site or administrative office. This system is linked to dumb or smart terminals at nonpublic sectarian schools where Chapter 1 students receive instruction directly from the computer.

OTA finds that while it is technically feasible to install and operate a distributed computer system, several important issues arise about the long term viability of this approach. These issues include substitution of computer systems for teachers and the tradeoff between flexible, stand-alone computers and a distributed system that must be externally operated to assure compliance with the law. There is also the issue of the costs for such a system: this includes not only hardware and software, but also telecommunications lines and transmission fees, and training of teachers at the LEA sites, and training of "monitors" at the delivery sites. It is important to assess how quickly these fixed systems might be replaced by superior technologies, as they represent a substantial investment in a hinge, dedicated hardware system. The continued evolution of computer hardware may provide new solutions to these questions, e.g., the recent advances in local area networks to link stand-alone computers in distributed networks.

OTA also finds advantages to this specific use of the technology as one remedy to the Aguilar v. Felton issue. Instruction can easily be monitored and student progress assessed using the management components of these systems. In addition, system uniformity provides a standardized instructional processor all students. Some districts already using distributed systems report significant achievement gains by students. Some also report lower per pupil costs.

IMMEDIATE AND FUTURE NEEDS

OTA finds four areas that need attention to improve the use of technology already in schools and to reach the potential that technology can offer. These are teacher training, software development, dissemination of information, and evaluation and research.

Teaeher Training

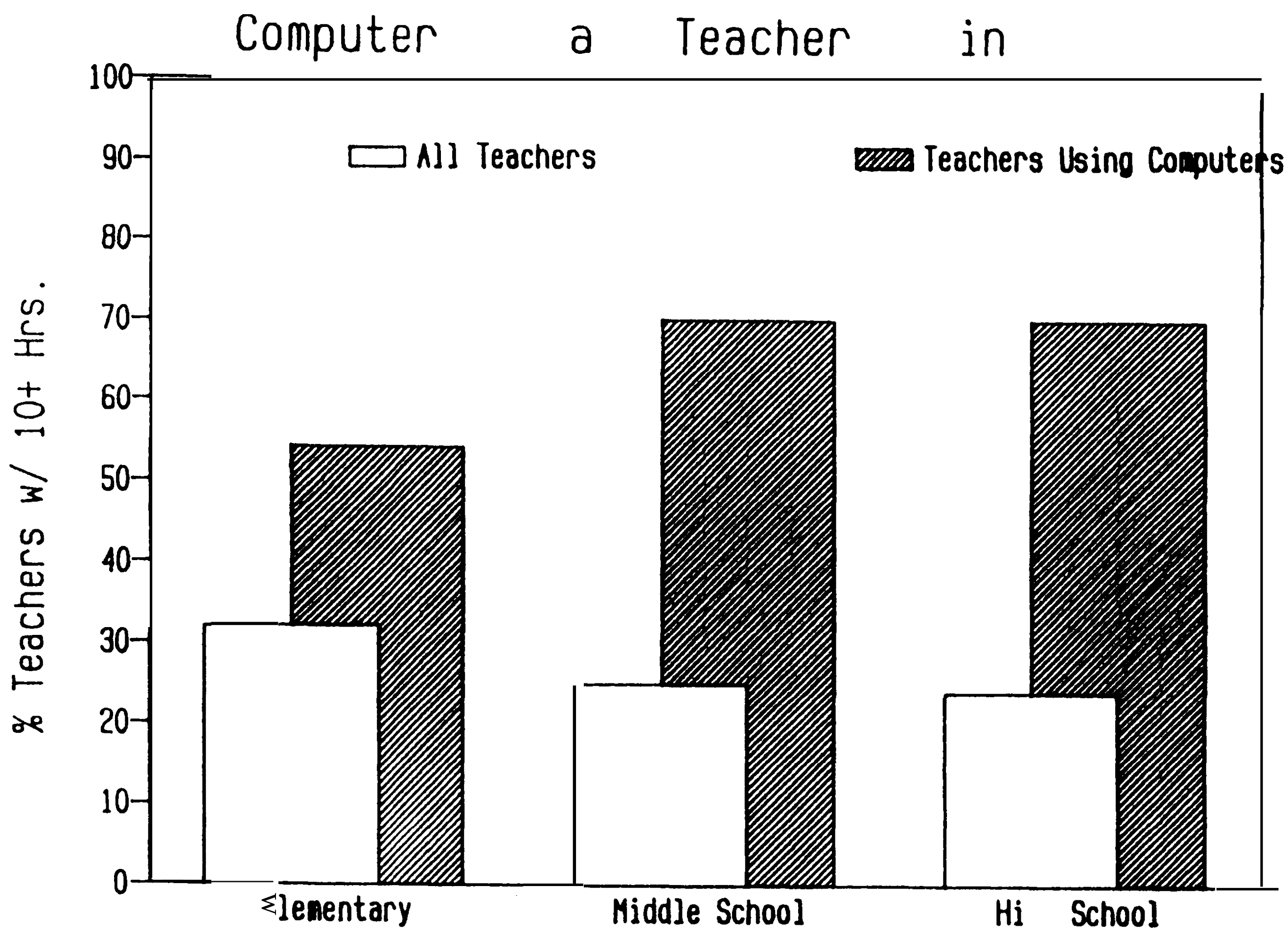
The expansion in the number of teachers using computers can be measured in many ways. One example of this growth is in the formation of self-help groups, such as Computer-Using Educators. In 1978, there were 50 educators who met together in various locations in and around the Silicon Valley; today there are over 8,000 members nationwide, and similar organizations in many States. In 1984-85, about 25 percent of all U.S. teachers used computers with their students. The most recent data show the number has grown to over 50 percent.

As more and more teachers use technology, perhaps the most important question is whether they have been adequately trained. OTA analysis of available data answer the question in part:

- Less than one-third of all U.S. teachers, but more than one-half of all computer-using teachers, have had at least 10 hours of training. [See Figure 16]

- Although teachers traditionally receive in-service training onsite, more than one-half of teachers who received training learned about computers in other ways: taking courses for college credit, attending training sessions offered by vendors, or in some other ways. [See Figure 17]

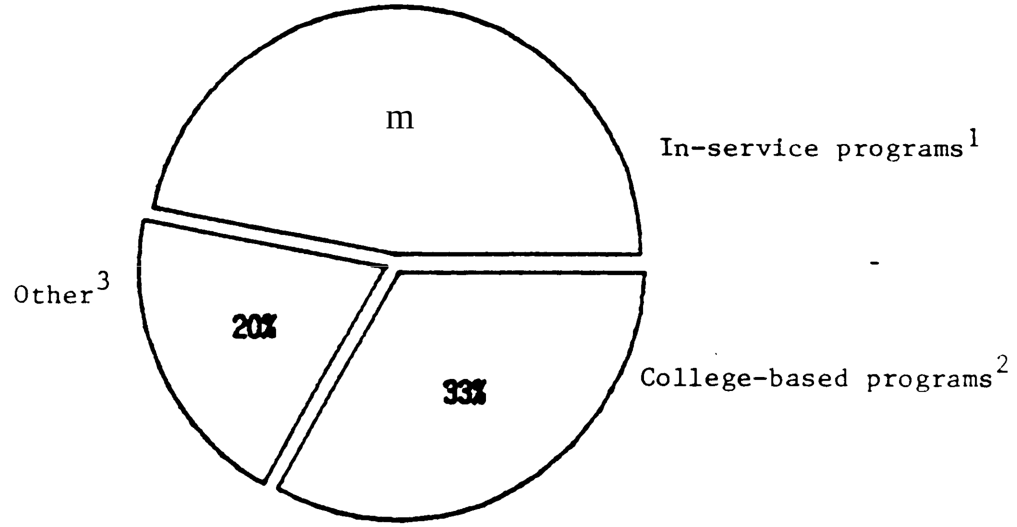
FIGURE 16



SOURCE: 1985 National Survey of Instructional Uses of Schools, Center for the Social Organization of Schools, Johns Hopkins University

FIGURE 17

Where Teachers Are Trained *



* Teachers with 10 or more hours of computer-related training.
1. In-service programs, typically offered on school premises.
2. In a college classroom for academic credit.
3. All other settings, including computer dealers.

SOURCE: 1985 National Survey of Instructional Uses of School Computers, Center for Social Organization of Schools, Johns Hopkins University.

- The majority of State Chapter 1 coordinators indicated that teacher training must be apart of any further investment in computer technology.

- Researchers and State and local policymakers in programs that serve limited English proficient (LEP) students emphasized the need for training in the application of programs to meet students needs, especially since so few software programs have been designed for such students.

As computer use in education has become more pervasive, State education agencies and local school districts are taking an active role in providing teacher training. There is general agreement that there is no quick and easy way to provide the training teachers need. To the extent that training relies on nonschool sources, there is concern regarding the ability of vendors to provide balanced information about appropriate software and about its best uses in the classroom. As development of more "user friendly" computer systems continues, along with increased use of content-related software, teachers will need a different kind of training. The issue of continuing teacher training is the one most frequently mentioned by educational researchers, computer manufacturers, software developers, and educational policymakers as the top priority to assure successful continuation of the use of computers in schools.

In view of continued training needs, there is a crucial need to identify practices that are working effectively and draw on the most recent research and evaluation of teacher training efforts.

Software

In the earliest days of computer purchases, many schools discovered that for a variety of reasons, there was a very limited range of software: (1) software written for one computer system would not run on any other; (2) most was of poor quality and had limited educational value; and (3) software programs tended to be electronic versions of drill and practice exercises found in workbooks.

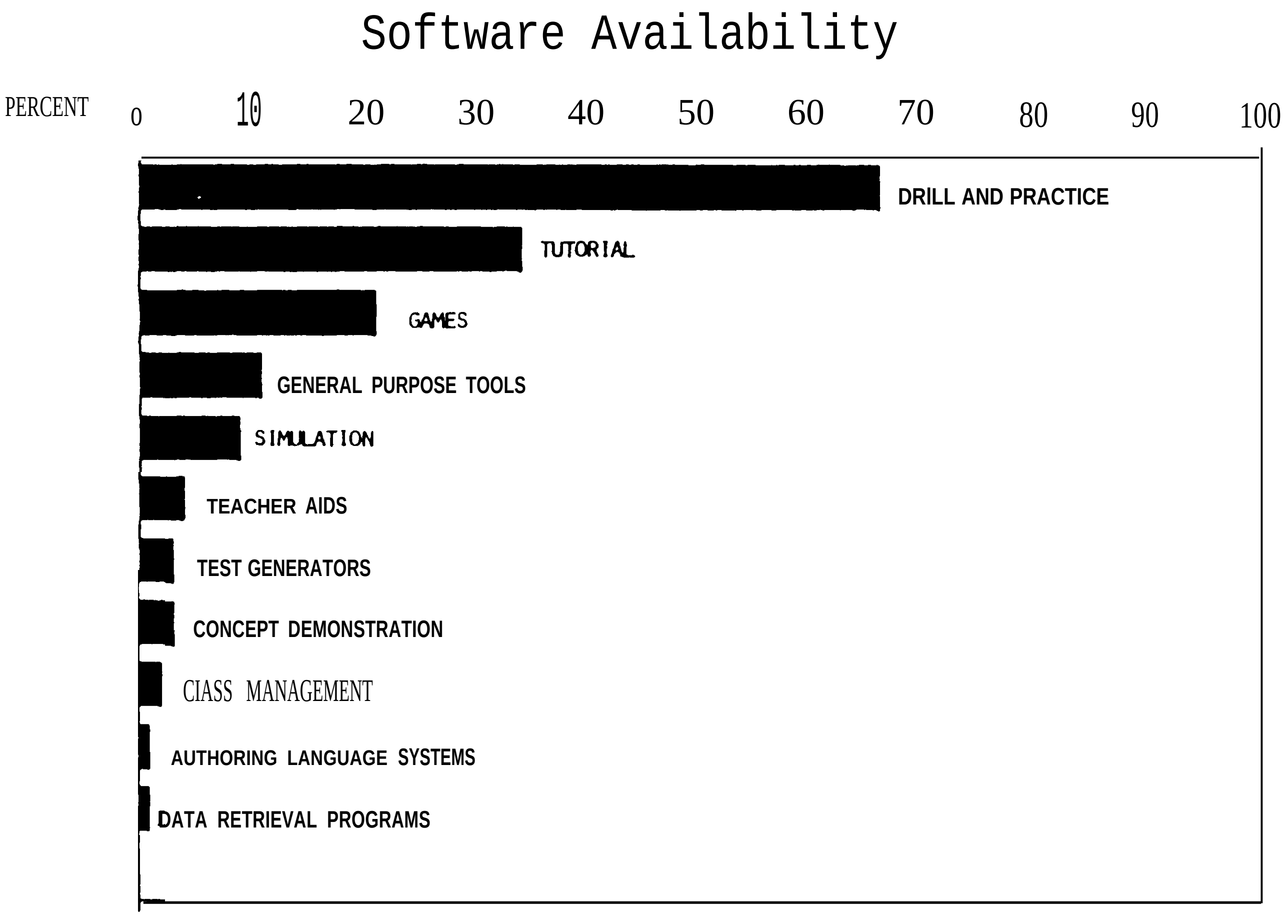
Today, educational software products are vastly improved and there is a wider range of content-related materials and types of application. [See Figure 19] Some software developers and publishers are able to produce software in more than one version to run on the major hardware systems in schools. As software has become available, schools have been quick to adopt and experiment with it. [see Table 1]

In Chapter 1 programs, software that offers both instruction and management of student progress appears to be working. At the same time, some Chapter 1 programs are experimenting with other applications and approaches. Some Chapter 1 managers question the need for experimentation, while others (including outside researchers) welcome such experimentation. The latter are concerned that Chapter 1 students may be limited by computer systems that simply drill them in skills at the remedial level, while other students get to use computers in many different ways and at various levels of functioning. A number of researchers suggest that Chapter 1 students may need more, not fewer, avenues to reach their potential level of development and full functioning.

In comparison to the range of software applications that are geared to remediation of basic skills, OTA finds that far less software has been developed for limited English proficient (LEP) students. This lack of specific software is a barrier to use of technology by the teacher with these students. However, OTA found examples of software that had been developed by the local district with a major infusion offending for development, or software developed by teachers themselves, to meet the specific needs of different language groups. Other programs are making effective use of word processing and writing tools that can be adapted for use in either ESL or bilingual programs.

OTA also finds that recent technological advances have positive implications for LEP students. These developments include: (l) low-cost chips, which add dual language

FIGURE 19



SOURCE: Baaed on data extracted from The Educational Software Selector (TESS) Database, May 1986, personal communication, Bob Haven, Educational Products Information Exchange (EPIE), Water Mill, NY.

Table 1

Distribution of Commercial Software Products by individual Subject Matter Areas

Subject Matter	Number of Software Products
Agriculture	16
Aviation	12
Business	189
Comprehensive[1]	536
Computers[2]	306
Driver Education	10
Early Learning-Preschool	150
English-Language Arts	751
English as a Second Language	34
Fine Arts	172
Foreign Language	305
Guidance	110
Health	92
Home Economics	113
Industrial Arts	
Logic and Problem solving	111
Math	1,646
Medicine	67
Miscellaneous	27
Physical Education	37
Reading	636
Religion	24
Science	1,013
Social Science	375

1. Generic software that can be used in all subjects.
2. Computer programming and computer literacy.

Source: Based on data extracted from <u>The Educational Software Selector</u> (TESS) Database, May 1986, personal communication, Bob Haven, Educational Products Information Exchange (EPIE), Water Mill, N.Y. Note: Haven estimates that a very small proportion of the software listed in TESS could easily be used by limited English proficient students.

character generation and make writing in Spanish or English possible on the same microcomputer; (2) digitized speech and audio devices, which make it possible to include native language speech output as a part of the microcomputer instructional program; and (3) dual audio tracks on video disk, which allow instruction of any subject in English and the native language.

Whether these technical capabilities will be utilized in developing resources for ESL and bilingual program applications is not certain. First of all, technology is still only a small part of these programs for LEP students. With limited funds available, most districts place priority on human resources (teachers and specialist staff). Second, software developers and distributors point to the thin markets for bilingual education and ESL materials. This factor discourages the investment of development dollars necessary to create software to suit varying needs of LEP students language minority speakers across the K-12 curriculum. However, there may be ways around some of these problems, such as seeding small scale development and encouraging development of general purpose software that can be customized for different language groups.

More generally, there may still be formidable barriers to effective software development. The marketplace for educational software is specialized, as State and district level curricula differ. The cost of researching, writing, designing, marketing, and distributing new software is significant. Some of the most successful programs are therefore, of necessity, widely applicable utilities like word processing and spreadsheets. Others fill specific niches that have been clearly identified. Some of the most effective and most used educational software programs were originally developed with Federal support. Many private software companies may not be able to recover the costs of development, due to the varying characteristics of the education market, to the nonstandard nature of educational purchasing practices, and to the widespread practice of illegal copying. The scope of this problem requires further study.

Dissemination of Information

As data show, computer use and application expanded at both elementary and secondary levels. At the same time, the technological environment is changing and becoming increasingly complex. Staying on top of lessons learned from widespread implementation efforts and keeping abreast of new hardware and software is very difficult even for those districts that are far ahead of most. State efforts such as the California computers in the curriculum project, local and regional networks of districts, and national computer user organizations play unimportant role. Nevertheless, these dissemination efforts do not reach all groups or cover all aspects of the information base.

OTA finds a need to disseminate information about programs using technology with LEP students. Several Title VII projects have information or materials of value but no resources to share them. Similarly OTA found researchers and schools making breakthroughs using technology with LEP students. It is important to ensure that dissemination agencies such as the National Clearing house on Bilingual Education, or the regional technical assistance centers, have the capacity to increase access to these important developments underway, and make use of this opportunity.

Chapter 1 technical assistance centers provide some training and information about technology to local districts. Several Chapter 1 programs using technology are part of the National Diffusion Network. Vendors and hardware manufacturers provide information as well. In spite of these resources, many State coordinators reiterated that they need more systematic information regarding the impacts of computer use.

Evaluation and Research

Because most implementation efforts focus on acquisition of technology and teacher training, evaluation has received less attention. Today, educators at all levels emphasize the need for more systematic evaluation of computer use. Many feel that there is a need to develop criteria that can be used to compare the variety of efforts taking place. Such criteria would make it possible to make better use of information that States and districts have collected, and identify critical components that are missing. Chapter 1 State coordinators stress the need for further research and evaluation. In addition, they see the need for demonstration sites, where advanced technology is integrated to meet the critical needs of Chapter 1 students. These sites need not be restricted to these students, but could include a wide range of approaches and a wide range of students, including LEP students. Those working with all of these students point to the need for research and development to create software for a variety of learning and language needs.

There may also be very valuable evaluation and research opportunities in a number of "experimental" demonstration efforts already in place. These include statewide activities such as Project Impact in Arkansas, and State supported demonstration projects and model sites in California and Minnesota, for example. In addition, it maybe important to follow what happens to students and teachers in a number of classrooms that have high concentrations of hardware provided by several vendors, such as the Apple Classroom of Tomorrow, Writing-to-Read, and the Waterford School. These experimental projects can provide a rich source of data for research and analysis.

CHAPTER 1

COMPUTERS IN AMERICAN EDUCATION: TRENDS AND STATUS

CHAPTER 1

COMPUTERS IN AMERICAN EDUCATION: TRENDS AND STATUS*

> Nobody really needs convincing these days that the computer is an innovation of more than ordinary magnitude, a one-in-several-centuries innovation and not a one-in-a-century innovation or a one-in-ten-years innovation or one of those instant revolutions that are announced every day in the papers or on television. It is an event of major magnitude.
>
> — Herbert Simon, in an address to a research conference on ‘Computers in Education: Realizing the Potential," August 1983

INTRODUCTION

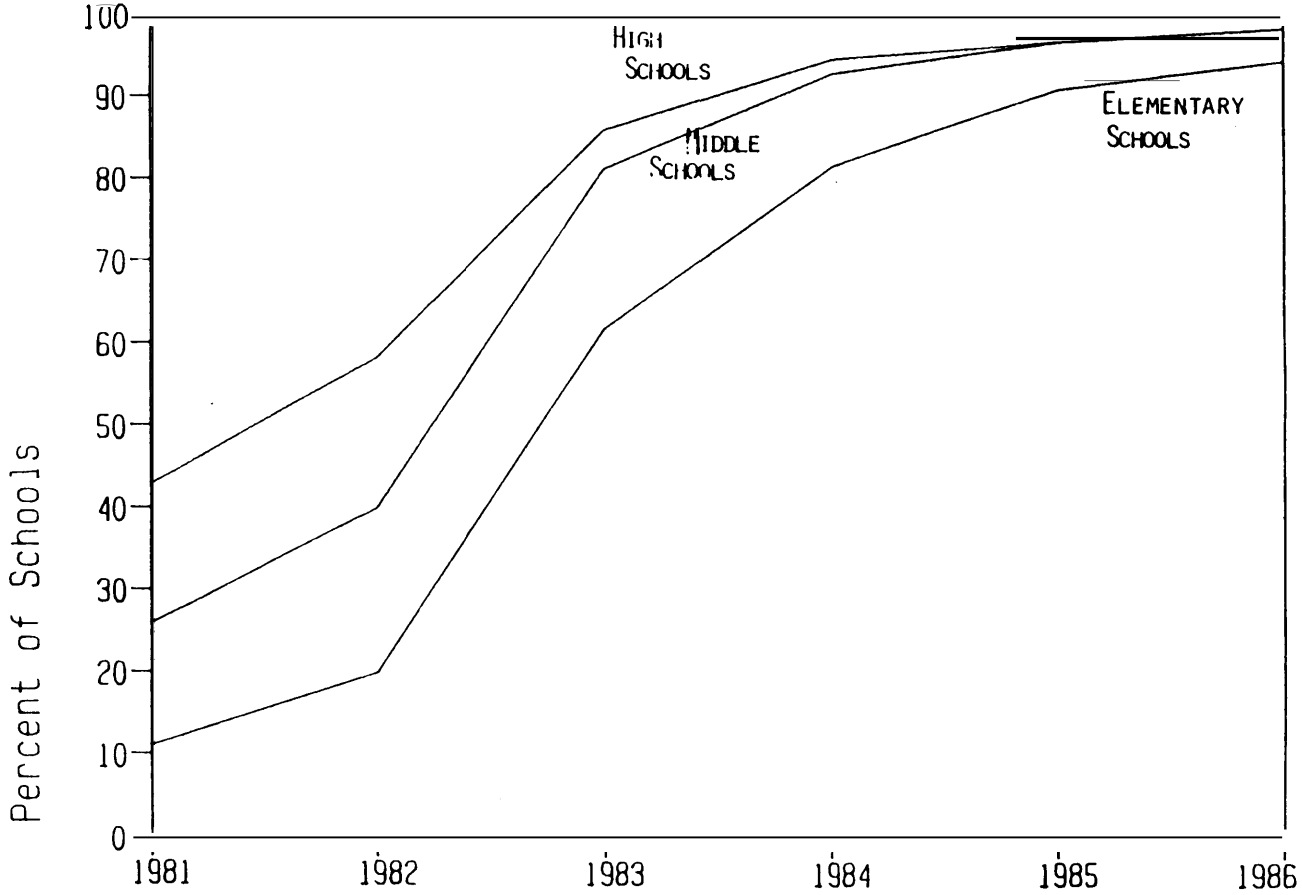
Between 1981 and 1986, the number of American public schools with computers intended for instruction grew from about 15,000 to about 77,000, or from about 18 percent of the total to almost 96 percent (see figure l-l). These figures represent a growth rate that may be unprecedented in the history of implementation of new technology: more than 95 percent of the schools without any computers in 1981 acquired at least one during the next 5 years, and in the first 2 years alone over 60 percent of the schools that had no computers became ‘computer-users." By the fall of 1985 there were already 15 million students and over 500,000 teachers using computers and related technologies for instruction in public and private schools. Estimates of the number of computers in use today range from a low of 1.1 million to a high of 1.7 million.

---

* This chapter provides a statistical overview of changes in the utilization of computers by U.S. elementary and secondary schools from 1981 to the present. It serves as the context for more detailed discussions of how technology is used in Chapter 1 programs and in programs for children with limited English proficiency.

FIGURE 1-1

Percent of Public Schools with Computers, 1981-1



SOURCE: Market Data Retrieval, Inc., Westport, CT, 1986.

This is an impressive record, that confirms the vision of Nobel laureate Simon, especially because of the way it was achieved: through a diverse and complex process that might be characterized as a "natural experiment" of dramatic proportions. In a period of less than 10 years, a wide range of computer-based technologies and software was introduced to students with enormously different intellectual and behavioral needs, by teachers and administrators of varied backgrounds, experience, and technical knowledge working in schools and school systems of significantly diverse demographic, ethnic, racial, and economic composition. As several State school officials put it, the fact that schools were willing to take on the challenge of integrating this nascent technology into their curricula is more important— and more optimistic—than the limited educational benefits that have been recorded to date.

Perhaps the most important policy implication of the rapidity and magnitude of this experiment is that it is too early to venture definitive and general pronouncements on the effects of computers in education. While some State and local school officials, as well as some researchers, have been conducting evaluations since as early as 1979, these studies have yielded mixed results, largely because of differences in the quality of data and in the methodology of evaluation. Many educators and policy analysts who are just beginning to collect and analyze data agree that some type of coordination that would lead to greater commensurability of research findings is sorely needed. Perhaps most important, it is quite possible that studies conducted today will generate data with limited relevance to technologies and applications that are just now emerging. There is general consensus that to evaluate the effects of a technology while it is still in a formative state may inhibit investments necessary to achieve desired advances in the technology and in its effective implementation.

On the other hand, it is not too early to begin the process of learning about the recent past, in order to gain clues to the types of choices that will be confronted in the future. Those choices often turn on economic, demographic, and institutional factors, which tend to change much more slowly than the technologies themselves, and which ultimately govern the success or failure of implementation. The purpose of this section is to provide background— in the form of a summary of choices that have already been made vis-a-vis distribution and application of computers—that can inform policy decisions that will be faced in the near future.

TRENDS IN DISTRIBUTION AND ACCESS1

By the beginning of the 1986/1987 school year, at least 95 percent of all public elementary schools had computers, along with almost 99 percent of all public middle and secondary schools; there were in the vicinity of 1.2 million computers installed in those schools. Private and sectarian schools are still running behind, with only about 77 percent of all such schools using computers for instruction.[2]

While these statistics on the distribution of computers provide part of the overall picture, they must be distinguished from measures of potential student access to computers in their schools. Potential access can be defined as the average ratio of students to computers in a given school, school district, or State, or for the entire country. It may be best to view this measure as a proxy for the congestion that would occur at any given computer or computer terminal: generally speaking, the higher the

1. The analysis in this chapter is basedon three principal sources of data: (l) original data from the 1985 National Survey of Instructional Uses of School Computers, conducted by the Center for the Social Organization of Schools at Johns Hopkins University, under the direction of Henry Jay Becker, as well as summaries found in the 'Instructional Uses of School Computers" newsletters, issues 1-3, 1986; (2) selected printouts from the 1984, 1985, and 1986 databases, as well as the 1985 survey entitled 'Microcomputers in Schools," by John F. Hood and co-workers at the Curriculum Information Center of Market Data Retrieval, Inc.; and (3) selected printouts from the 1986-1987 database compiled by Quality Education Data, Inc., as well as the summary volume entitled 'Microcomputer and VCR Usage in Schools, 1985-1986," edited by Jeanne Hayes, 1986. Sampling methods and other characteristics of these data sources are discussed in the notes on data and methodology at the end of this chapter.

2. Data for public schools were collected during the summer of 1986, and may therefore underestimate the Fall inventory of computers; data for private and sectarian schools were collected between January and March.

ratio of students to computers, the less time each user would have to work with the computer. Alternatively, one can use a measure of computers per student, although computers per 30 students —which is used in this report—links access to typical classrooms of students and has been found to be quite illustrative. * The word "potential” is used because even a relatively low student/computer ratio or a relatively high ratio of computers per 30 students may not be sufficient to guarantee access, if other organizational conditions in the school are not met.

Access to computers has, necessarily, improved because of increasing investments by schools in hardware. However, while it is true that schools often purchased or acquired equipment in clusters— as Becker put it, ‘schools had learned that they needed large numbers of computers if [they] were to be more than showpieces "—the rate of change in potential student access has not been as dramatic as the rate of change in the number of schools with at least one computer. Between 1983 and 1986 the national average dropped from about 92 students per computer to about 37 students per computer, representing an average annual rate of change of about 26 percent (see figure 1-2). But perhaps more important is the fact that as of 1985 only half the computer-using high schools and about 6 percent of the computer-using elementary schools had 15 or more computers in any one room.**

Perhaps the most striking feature of these data is the story they tell about the net effect of early allocation and distribution decisions. Given the choice between a decentralized system of widespread distribution of the technology to as many schools as possible, or more coordinated and concentrated distribution of specific hardware and software to user groups with particular needs, the efforts of parents, teachers, and

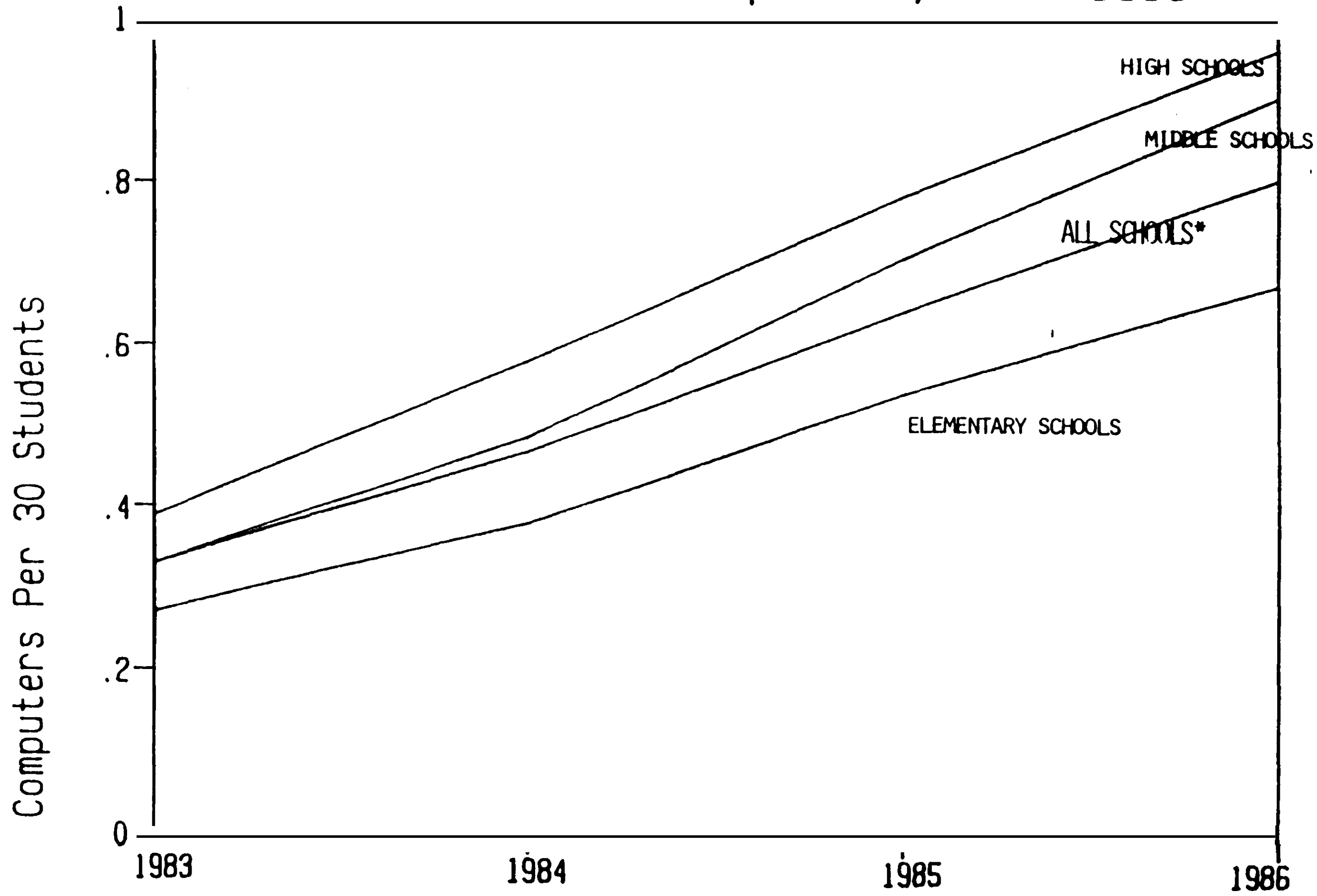
---

* This measure was suggested by Becker, who also experimented with a variety of access measures with differing statistical properties.

** Based on these figures, Becker argues that even though many schools were acquiring new technology, the quantities were not sufficient to allow all or even half the students in a typical class access at the same time. He questions further whether under these circumstances teachers could have applied the new tool effectively without a dramatic reorganization of traditional classroom-based modes of instruction.

FIGURE 1-2

Student Access to Computers, 1983-1986



* INCLUDES K-12 COMBINED SCHOOLS

SOURCE: Market Data Retrieval, Inc., Westport, CT, 1986.

school systems nationwide generally favored broad diffusion.

Some observers have argued that this choice was misdirected: from the beginning there could have been better planning and more selective introduction of computers in sufficient quantity to guarantee users the time necessary to accomplish well-defined objectives. According to these critics, this would have been a more effective strategy than putting one or two computers in as many schools as possible without specifying how they would reutilized, by which students, and in the context of which curricula.

Others would counter by emphasizing that little was known about the "best" uses of computers at their inception, and that attempts to allocate available technological resources more "rationally" might have further restricted the availability of information about students' learning, teachers' instructional styles, and appropriate means of integrating available software into the curricula. In addition, had early computer use been limited to populations of students with specific educational needs, or to clearly defined educational objectives that were achievable through computers, the development of software applicable to a wide range of subjects might have been substantially impeded. As long as schools could adapt to the new technology and process new information about applications and integration as it became available, decentralized and large-scale distribution would serve not only to expose many students to computers, but would provide data on multiple approaches to implementation. To the great credit of schools, which, as several State superintendents have emphasized, were never officially designated as the institutions through which computers would enter the mainstream of American life, there now exists a foundation upon which to structure more thorough analyses that will inform the next stages of implementation.

SOURCES OF VARIATION IN ACCESS AND USE

School Size and Classroom Organization

It is important to keep in mind that the overall pattern of mass distribution, as opposed to more concentrated applications, was not uniform across all schools and in all regions of the country. Some schools chose to situate their computer resources in clusters, thereby enabling teachers to use them with all or most children in their classes. At other schools, usually at the elementary level, computers have been installed in as many rooms as possible. These early allocation decisions were based largely on intuitive judgments of teachers and administrators — as to how a small number of computers could be used effectively. Elementary and secondary schools chose different strategies because the former are structured to present a variety of material to fixed groups of children, usually by a single teacher, while the latter are organized to teach specific subjects by specialized teachers. Flexibility in implementation, or the ability of teachers and schools to decide how computers can be applied toward the specific needs of their students, is an important feature of decentralized allocation. But it must be emphasized that the provision of accurate and current information, which is necessary for decentralized systems to function efficiently, requires some form of planning. Many researchers have expressed the wish for governmental intervention to help organize more systematic collection and dissemination of data from the diverse experiences of school systems that have placed computers in classrooms, laboratories, libraries, and other physical environments.

School size (number of enrolled students) is a significant correlate of computer ownership and pupil access. Smaller schools typically have fewer computers than larger schools: in a typical small elementary school (less than 250 students), for example, there were about 4 computers in 1985, while in the median large elementary school (over 500 pupils) there were 9 computers. Nevertheless, potential access is usually greater in the smaller schools, because they have proportionally more computers than larger schools. Thus, while the typical small high school had about 13 computers in 1985, compared to the typical large high school that had 38 computers, the student — computer ratios in those schools were 19:1 and 38:1; respectively (see Table 1). This result has been labeled the ‘enrollment penalty factor"[3] to suggest that students in larger schools are often at a disadvantage — vis-a-vis computer access — because of their school’s size, all else equal.*

It is important to keep in mind, however, that while a school with 300 students and three computers has abetter ratio (100 students per computer) than a school with 2,250 students and 15 computers (150:1), access may actually be superior in the latter school: if the school building is more modern and has better facilities, or if the greater number of computers means fewer interruptions due to mechanical failures, then children in the larger school may have better access.

Systematic evaluations of schools of varying size (and other attributes) are necessary to resolve this important question. In the meantime, though, it is clear that allocation decisions cannot rest solely on quantitative measures such as student/computer ratio or average number of computers per school, but must also take into account qualitative factors: how to best integrate the computers given the constraints of classroom organization.

---

3. Jeanne Hayes, Microcomputers and VCR Usage in Schools, 1985-1986 (Denver, CO: QED, Inc., 1986).

* Given that large schools are often found in urban areas, black students and others who are disproprortionately represented in those schools experience worse access to computers than those who typically attend smaller schools. This issue is discussed in greater detail below.

TABLE 1

SCHOOL SIZE, COMPUTER INVENTORY, AND PUPIL ACCESS

	small		Medium		Large	
	Average Number of Computers	Average Number Students/Computer	Average Number of Computers	Average Number Students/Computer	Average Number of Computers	Average Number Students/Computer
Elementary	**4**	**32**	7	53	9	77
Middle School	**12**	**28**	16	38	19	53
High School	13	18	24	31	38	38

Notes on Designation of School Size:

	Small	Medium	Large
Elementary	1-249	250-500	501+
Middle School	1-499	500-750	751+
High School	1-499	500-1000	1001+

SOURCE: 1985 National Survey of Instructional Uses of School Computers, Center for the Social Organization of Schools, John Hopkins, University.

Socioeconomic Status

The apparent disadvantage of children in large schools can be mitigated, to some " extent, by socioeconomic status. QED's "lifestyle selector" model** shows that children in highly educated, affluent neighborhoods typically attend relatively large schools, but that they experience the same high rate of access to computers as children in rural areas whose schools are typically small. Thus, in these schools, unlike similarly large schools attended by other population groups, high socioeconomic status outweighs the "enrollment penalty" (see figure 1-3).

Indeed, one of the more common anxieties over the use of computers in schools was perhaps best captured by the TIME MAGAZINE headline that asked, "Will the rich get smarter while the poor play video games?"[4] This question expresses the disturbing possibility that children in rich schools have greater access than those in poor schools. While it is true that certain discrepancies still exist between rich and poor, the available data suggest that the gap between rich and poor schools with computers has been narrowing. In 1981, only 12 percent of the schools in the country's poorest school districts had computers, compared with 30 percent of schools in the richest districts, but by 1986 the gap had narrowed to just seven percentage points: 91 percent of schools in the poorest districts and 98 percent of schools in the richest districts had computers. It should be emphasized, however, that poor schools <u>without</u> computers in 1981 were slower to obtain them than richer schools. In the 5-year period that followed, 90 percent of noncomputer-using poor schools, and 97 percent of rich schools, acquired some computers. Taken together, these statistics suggest that poor schools did not gain

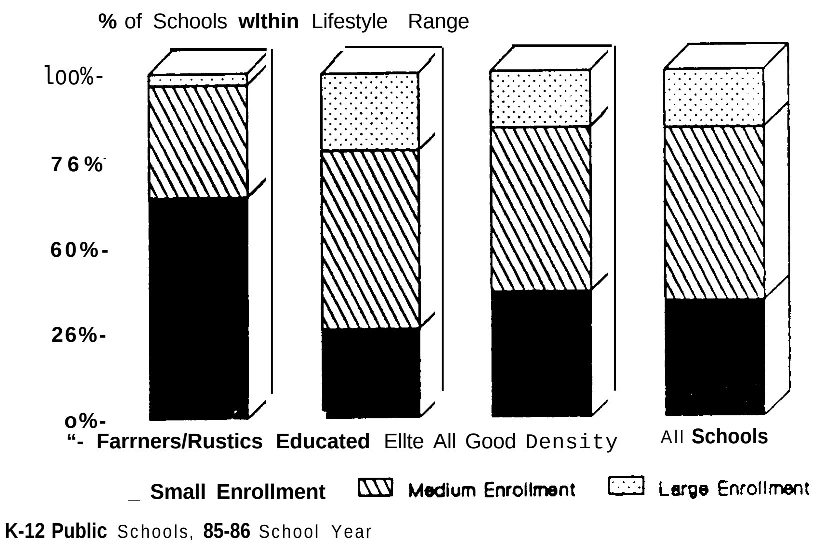
---

** Based on a procedure developed by Claritas, a Washington-based demographics research firm. See notes on methodology and data, part c at the end of this chapter.

4. Henry Becker cites this article in his paper "Equity in School Computer Use: National Data and Neglected Considerations," presented at the annual meetings of the American Educational Research Association, San Francisco, April 1986.

FIGURE 1-3

SCHOOL SIZE AND "LIFESTYLE SELECTORS"



SOURCE: Microcomputer and VCR Usage in Schools, 1985-1986, QED, Inc., Denver, CO, p. 31, reprinted with permission.

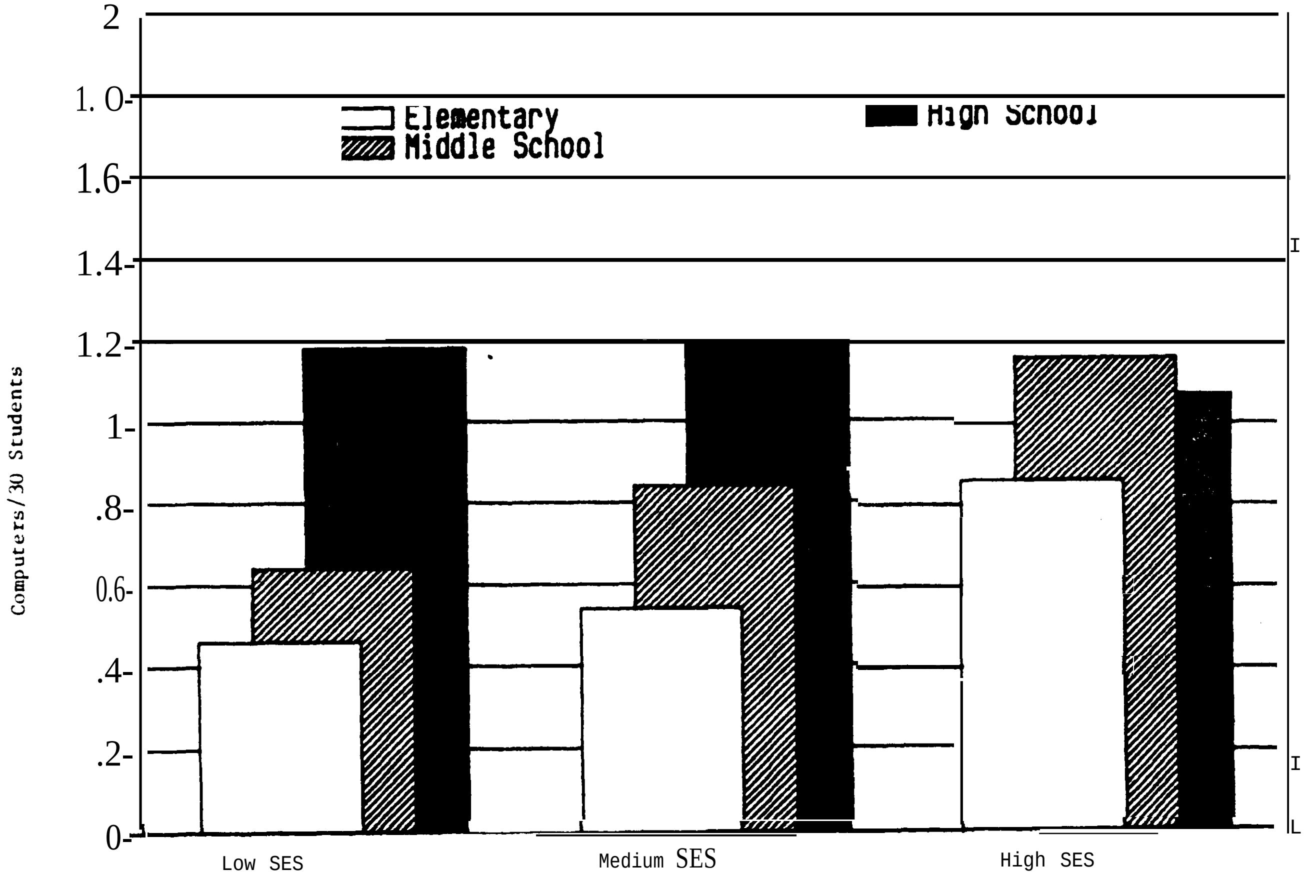
equipment as rapidly as rich ones, but that there are now few schools — rich or poor — with no computers.

Potential access to computers, in general, has favored children in relatively wealthier schools and school districts. In elementary schools where the majority of students are in a high socioeconomic bracket (measured by an index of parents' occupations and incomes, as estimated by the school's principal) there is an average of one computer for 35 children, while in poorer schools there are about 65 children per computer. This is a sizeable difference, and is as great in junior high schools (a student/computer ratio of 27:1 in rich schools compared to a ratio of 47:1 in the poorest schools). But the trend disappears at the high school level: students in the poorest schools seem no worse off than those in the richest schools. It is striking to find no evidence in the high schools of the predicted distribution pattern observed in the lower grades. (see figure 1-4)

Regional Variations

Computer access varies from State to State (see figure 1-5). Moreover, the type of unexpected result reported above — that poorer students do not always have inferior access to computers — is found in cross-State Comparisons. For example, in California the student/computer ratio in the richest school districts is about 32:1 while in the poorest districts it is about 48:1. But in Michigan the difference is much smaller: in poor districts there are on average only two more students per computer than in rich districts. There are some States where the ratio is substantially better in the poorest districts: in Oregon there are on average 20 fewer students per computer in the poorest districts than in the richest (the ratios are, respectively, 19:l and 39:1). It is important to consider economic and demographic conditions that might account for these differences, and to explore how specific State policies have influenced the equity of access across districts of varying wealth.

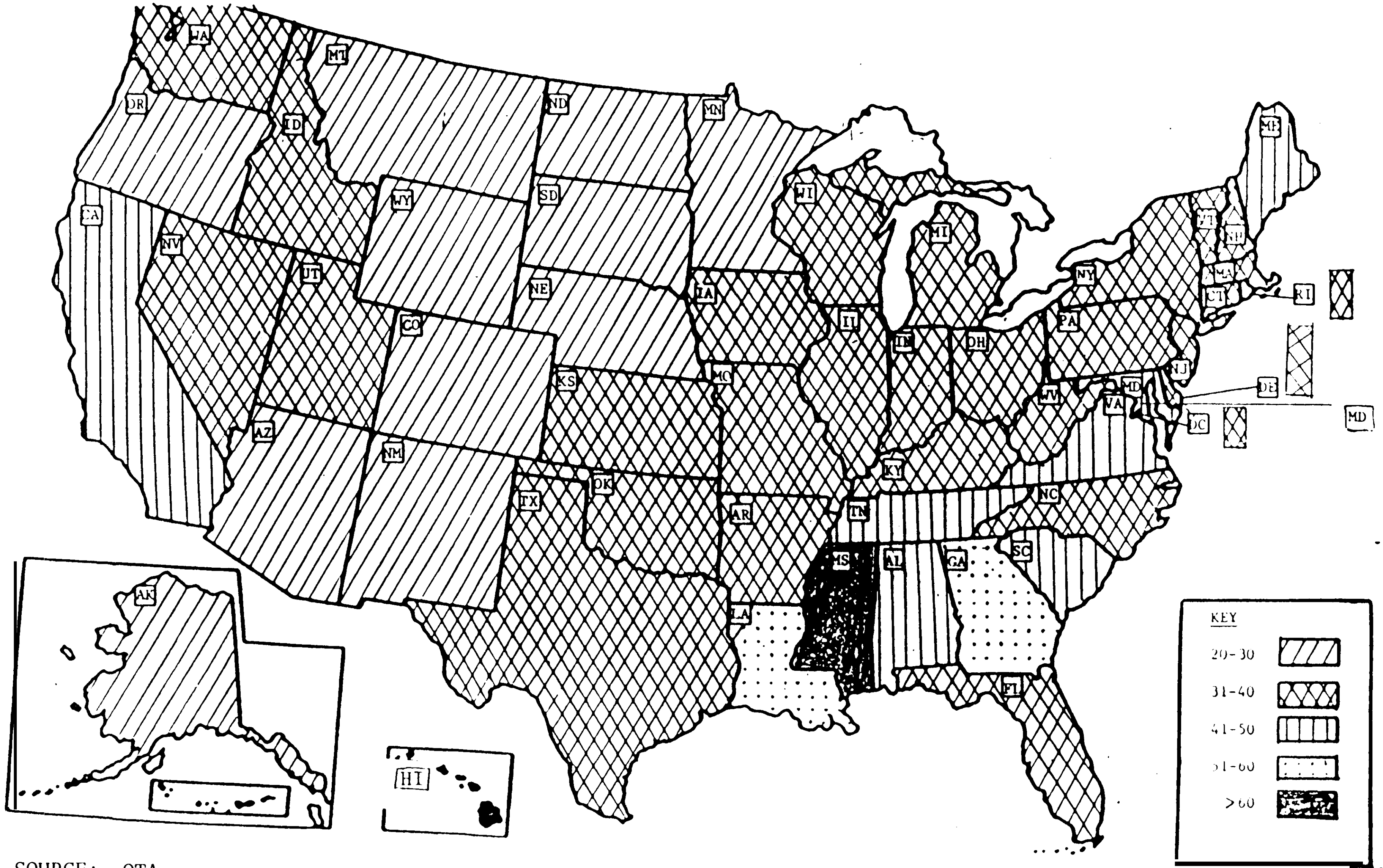
FIGURE 1-4
SOCIOECONOMIC STATUS* AND ACCESS (1985)



*SES measure based on school-wide index of parents' occupations and incomes
SOURCE: 1985 National Survey of Instructional Uses of School Computers, Center for the Social Organization of Schools, Johns Hopkins University.

FIGURE 1-5

CROSS-STATE DIFFERENCES IN AVERAGE NUMBER OF STUDENTS PER COMPUTER, 1986



SOURCE: OTA

In this regard, data on regional varaions can be useful as indicators of differences in implementation strategy or in philosophy regarding the most effective ways to integrate technology with curricular objectives? In the typical western high school, for example, there is roughly one computer for every 23 students, which suggests a high level of use; but the West also has the lowest percentage of schools that require a course or unit about computers. The Northeast emphasizes computer literacy for elementary school children much more than for high school children, while in the Midwest the main thrust is at the high school level. (See figure 1-6) Moreover, it seems that in less densely populated areas, computer literacy courses are more likely to be required in high school than in the lower grades; in urban areas, the greatest concentration of computer literacy courses occurs at the middle school level.

These differences in the degree and timing of courses in computer literacy are especially important because of the growing sense among educational researchers and computer scientists that initial emphasis on computer literacy and programming may have been misguided. The more proper focus of computer-based education, in the opinion of many experts, is in utilities (such as word processing or database management), problem solving, and software that can be integrated to teach regular subjects in the curriculum.[5]

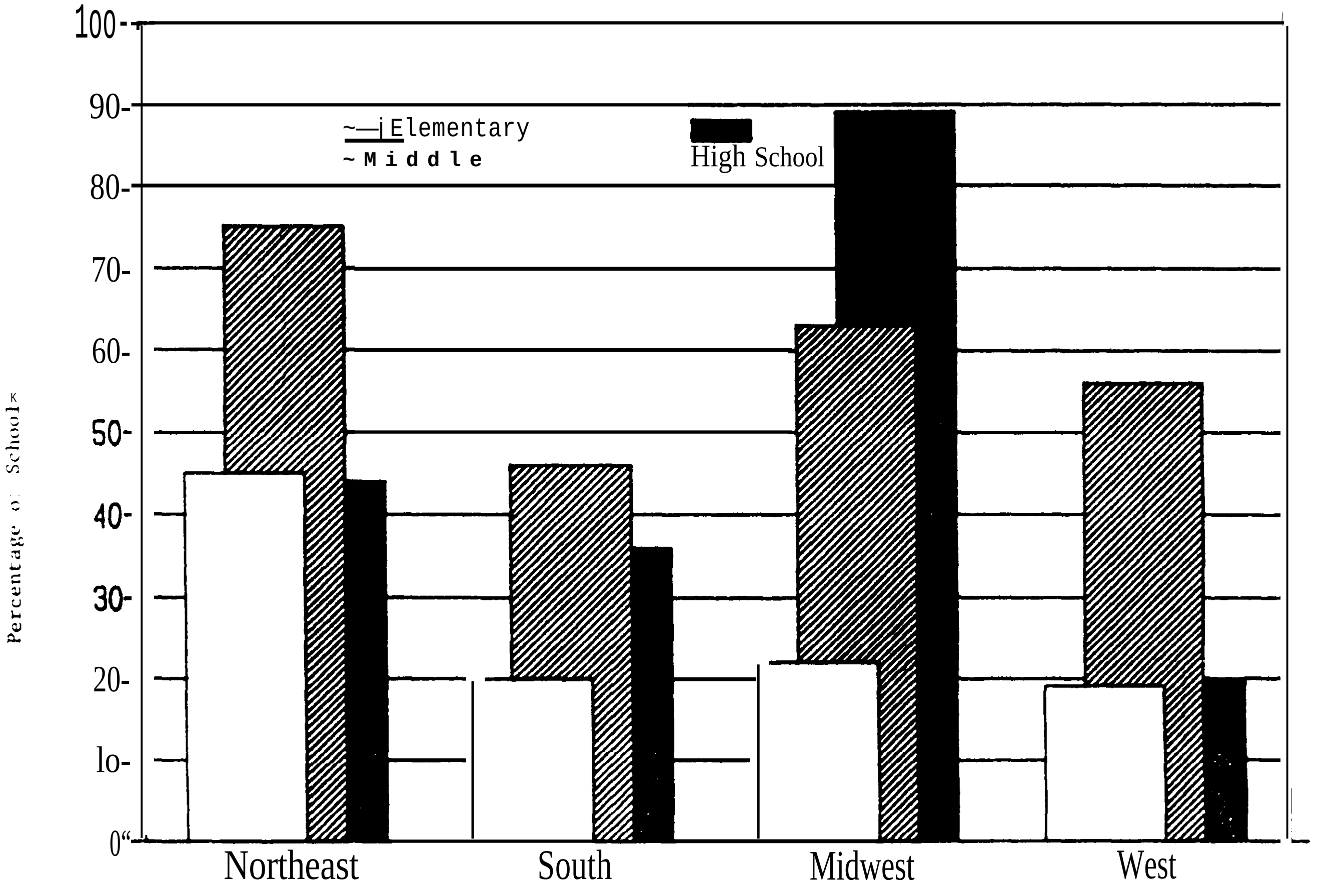
Racial and Ethnic Differences

The effects of socioeconomic status were noted above. Given that race and socioeconomic status are correlated — black children are more likely than whites to attend poor schools — it would not be surprising to find significant differences in the

---

5. This argument is fleshed out in detail in J. Capper, cd., The Research into Practice Digest, vol. 1, No. 3, spring 1986. See also National Commission for Employment Policy, "Computers in the Workplace: Selected Issues," Report # 19, March 1986, which argues that elementary and secondary school students do not need in depth computer training "since most of their computer training will take place after they have jobs." The relative proportion of instructional time devoted to various applications is addressed below, in the section on instructional applications.

FIGURE 1-6
REGIONAL VARIATIONS IN COURSE REQUIREMENTS*



*Semester-long courses in computer literacy or programming.

SOURCE: 1985 **National** Survey of Instruction Uses of School Computers, Center for the Social Organization of Schools, John Hopkins University.

access to computers experienced by black and white students. However, the effects of race are not uniform in all schools, and have been diminishing with time.

First, controlling for socioeconomic status, achievement, school size, and school location — all of which predictably influence computer use and access — Becker found that predominantly black elementary schools were significantly less likely that predominantly white schools to have a computer in 1985.* Note, however, that by now very few schools have no computers, which means that this result was more significant in 1985 than it is today.

Second, among schools with computers, there was little difference in the number of computers at black schools and white schools. But here the effect of school size plays an important role. Since blacks typically attend larger schools, the available hardware must be shared among a greater number of students. Holding constant the effect of enrollment, the relationship between racial composition and pupil access weakens considerably, and using some measures disappears entirely.

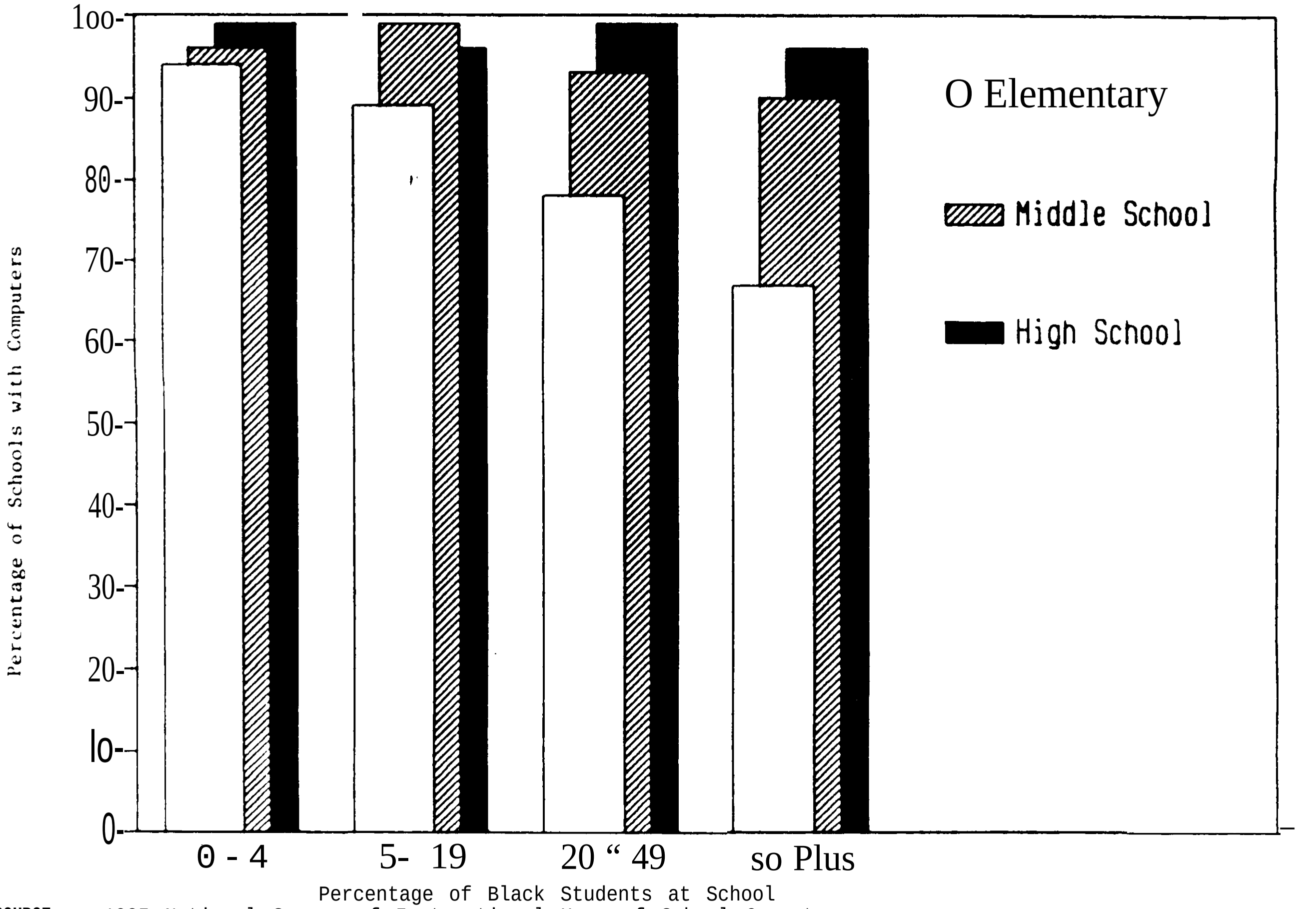
Third, there is no evidence that computers in black schools are used for longer periods of time than those in white schools; thus, not only do black students typically have lower access than whites, they also have less time on the computers than students in predominantly white schools. Note, however, that these deficits in access and intensity are experienced primarily in elementary schools and to a much lesser extent in high schools. (see figure 1-7)

Finally, teachers in 1985 were significantly less likely to use computers in predominantly black schools than in other schools, particularly at the elementary school and middle school levels. Becker reports that the typical white student attends a computer-using school that has 50 percent more computer-using teachers than in the school attended by the typical black student, controlling for both the school enrollment

* In a multiple regression model that included 10 explanatory variables, "percent Black students" used the strongest (negative) effect on the likelihood of a school using computers.

Figure 1- 7

SCHOOLS WITH COMPUTERS : DIFFERENCES IN STUDENT ACCESS AS A FUNCTION OF RACIAL MAKE UP OF SCHOOLS



SOURCE : 1985 National Survey of Instructional Uses of School Computers, Center for the Social Organization of Schools, Johns Hopkins University.

and the school's computer inventory.[6]

Taken together, these data suggest that while discrepancies between black and white students persist, some components of the gap have narrowed. To the extent that racial discrepancies are difficult to disentangle from socioeconomic factors and diverse educational needs, it is important to consider not only school inventories and potential access, but also whether students of different racial and ethnic backgrounds use computers to learn different subjects and skills. This matter is treated separately below, under "Instructional Applications."

Gender Differences

These types of measures — number of schools with computers and ratio of students per computer —are often cited as evidence of disparities between children in different types of schools and between children of different socioeconomic status and race. But it is important to keep in mind that apparent inequalities of this sort do not necessarily reflect inequities in the actual experiences of students with computers. While a school with 300 students and three computers has a better ratio (100 students per computer) than a school with 2,250 students and 15 computers (150:1), access may actually be superior in the latter school: if the school building is more modern and has better facilities, or if the greater number of computers means fewer interruptions due to mechanical failures, then children in the larger school may have superior access.

An important example of how institutional factors influence computer use is the differences experienced by male and female students. Here, especially, access — as measured by the student/computer ratio — is less significant than other features of computer implementation. For example, Becker found that where the computer was tied formally to curricula, male dominance in computerese was substantially eliminated. In some schools male students dominate all aspects of computer use, and in a very few

6. Becker, op.cit.

schools do females dominate in any type of use (except high school level word processing). However, in elective programming classes, and especially in those with advanced algebra or higher mathematics, boys and girls were evenly split. Even in word processing classes, while girls tended to dominate in high schools, there was an even distribution at the elementary and middle school levels. Game playing and use of the computer during nonschool hours, on the other hand, is substantially dominated by boys.

INSTRUCTIONAL APPLICATIONS OF COMPUTERS

How have computers been integrated into the curriculum? As noted earlier, when schools first began to acquire computers they used them primarily to teach students <u>about</u> computers, and only to a very limited extent as a tool to enhance learning of regular subjects. To this day, schools with more computers clustered in a single classroom tend to spend more time on programming, a fact that is easily traced to schools' initial investments in computer laboratories intended primarily to teach computer literacy and programming. It is really only since 1985 that schools have begun to devote their laboratories to other purposes.

Indeed, some observers have lamented that computer literacy and programming courses, which attracted a small and fervent band of computer aficionados,* may have intimidated the larger population of students and set back the integration of computer-based systems into the general curriculum by several years. It must be remembered, however, that in the absence of software that could be used for teaching regular subjects, the initial focus on programming was predictable; and some of the programming "buffs," who were instrumental in developing software that could be used for nonprogramming applications, have gone on to head district and Statewide efforts in

---

* In common parlance these kids became known as "nerds" who were said to spend their days in "hacker heaven," i.e., computer classrooms or labs where they could pass endless hours programming and debugging whatever software was at their disposal.

computer-based education.

As more and better software became available, it was quickly adopted, often on a trial basis, in many schools. In this regard, too, the experience of the past 5 years may be best understood as a large experiment: the latest issue of the 'Educational Software Selector"[7] is close to 1,000 pages long and contains descriptions of hundreds of software options for all possible subject areas. With rather limited data on the effects of these various programs and packages, it would be premature to declare which types of software are best suited for the school market; rather, it is imperative that evaluations continue and that their results be tabulated and disseminated as systematically as possible.*

As of 1985, student instructional time spent with computers overall was divided almost evenly between drill and practice, programming, and all other uses, including problem solving "discovery learning") and word processing. In the elementary grades most time is spent with drill and practice, while in middle and high schools the pattern shifts toward more time on programming and word processing. Children in elementary school spend more time with programs intended to improve basic mathematics and reading skills— via computer/drill and practice— while high school students spend considerable amounts of time with business software. (See figure 1-8)

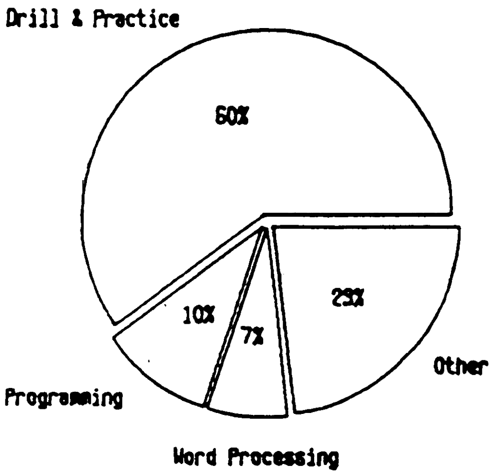
This basic pattern is stable regardless of school size, but varies with schools' socioeconomic status and achievement level. Thus, for example, schools with a higher proportion of poor children tend to spend more time with drill and practice than schools with a wealthier student body, especially at the middle school level. Similarly, children

---

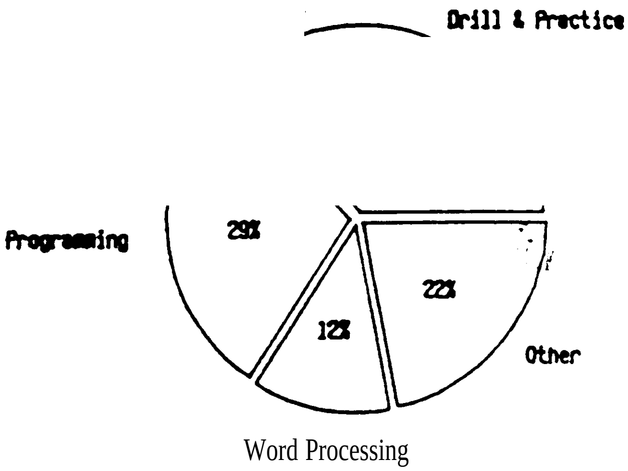
7. EPIE Institute, Teachers College Press, Columbia University, New York, 1986.

* An area of critical concern is the viability of the market for educational software. While large developers have been able to risk investments in new products, it would be unfortunate if economic barriers prevented smaller companies from exploring new and risky avenues of research and development. See Henry Levin and Gail Meister, 'Educational Technology and Computers: Promises, Promises, Always Promises,[H] Project Report No. **85-A13,** Institute for Research on Educational Finance and Governance, Stanford University, November 1985; and Office of Technology Assessment, U.S. Congress, Intellectual Property Rights in an Age of Electronics and Information (Washington, DC: U.S. Government Printing Office, April 1986). This problem will be addressed in greater depth during **OTA's** ongoing assessment.

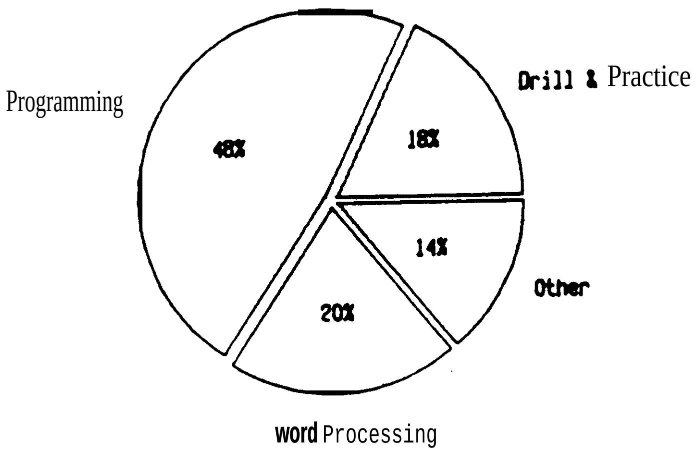
Elementary Students



Middle School Students



High School Students



SOURCE: 1985 National Survey of Instructional Uses of School Computers, Center for the Social Organization of Schools, Johns Hopkins University.

in poor schools and children in schools with a large percentage of below-average students, spend considerably less time on programming than those in wealthy schools and those in schools with many high achieving students (see figure 1-9, 1-10).

Socioeconomic status and achievement— measured in terms of the percentage of students who perform below the mean for their grade level—are both negatively correlated with the amount of time spent on drill and practice and are positively correlated with the time spent on programming. In other words, children in relatively affluent and/or relatively high-ability schools tend to spend relatively more time on programming and relatively less time on drill and practice. However, the data suggest no correlation between racial composition of schools and the time spent on various types of applications, controlling for socioeconomic status and achievement. This means that observed differences between schools of varying racial mix, in time devoted to CAI (drill and practice), programming, and other applications (such as word processing) have more to do with differences in schools' socioeconomic characteristics and with different educational needs of children whose prior achievement levels differ, than with the school% racial composition. In this regard, Becker reports that schools at which black students are the majority are only slightly more likely than all-white schools to use computers for drill and practice rather than for computer programming instruction.

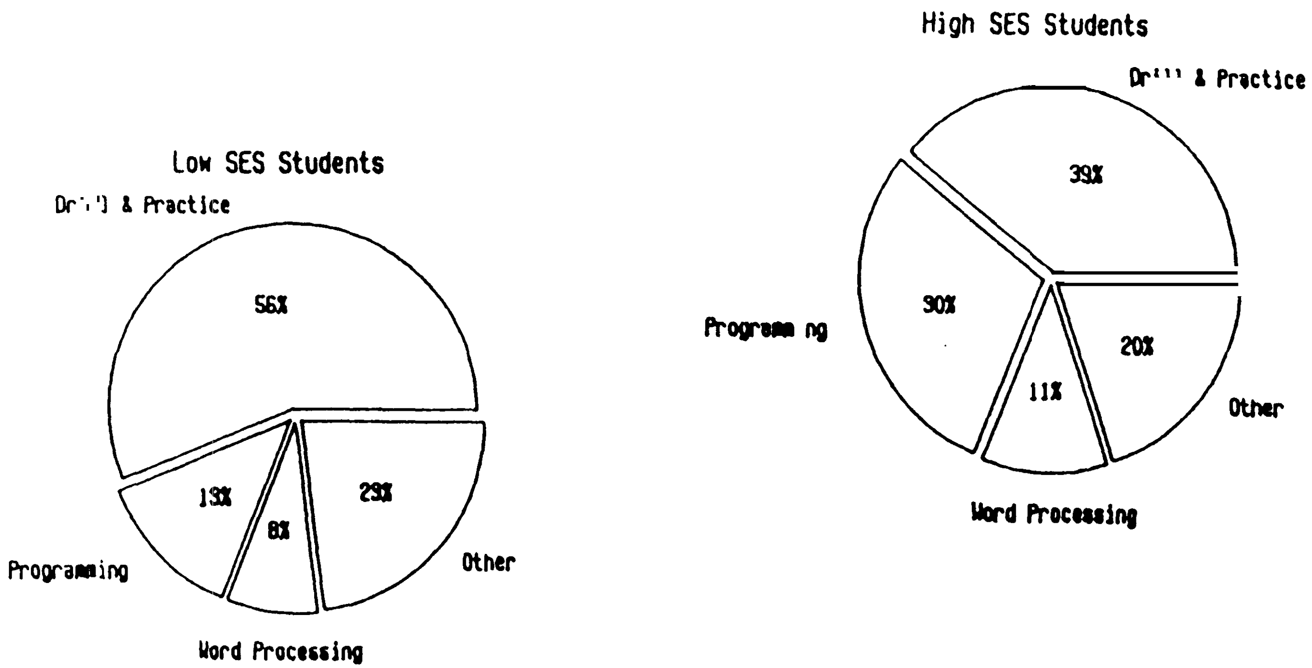
TEACHERS: TRAINING AND EXPERIENCE

The expansion in the number of computers used for instruction between 1983 and 1985 was nearly matched by the increase in the number of teachers using computers. As of 1984-85, about one-fourth of all U.S. teachers used computers with their students; according to more recent data, that number may have already grown to over 50 percent.[8]

The propensity of teachers to use computers depends on a variety of factors. For example, a higher proportion of elementary school teachers used computers than

FIGURE -9

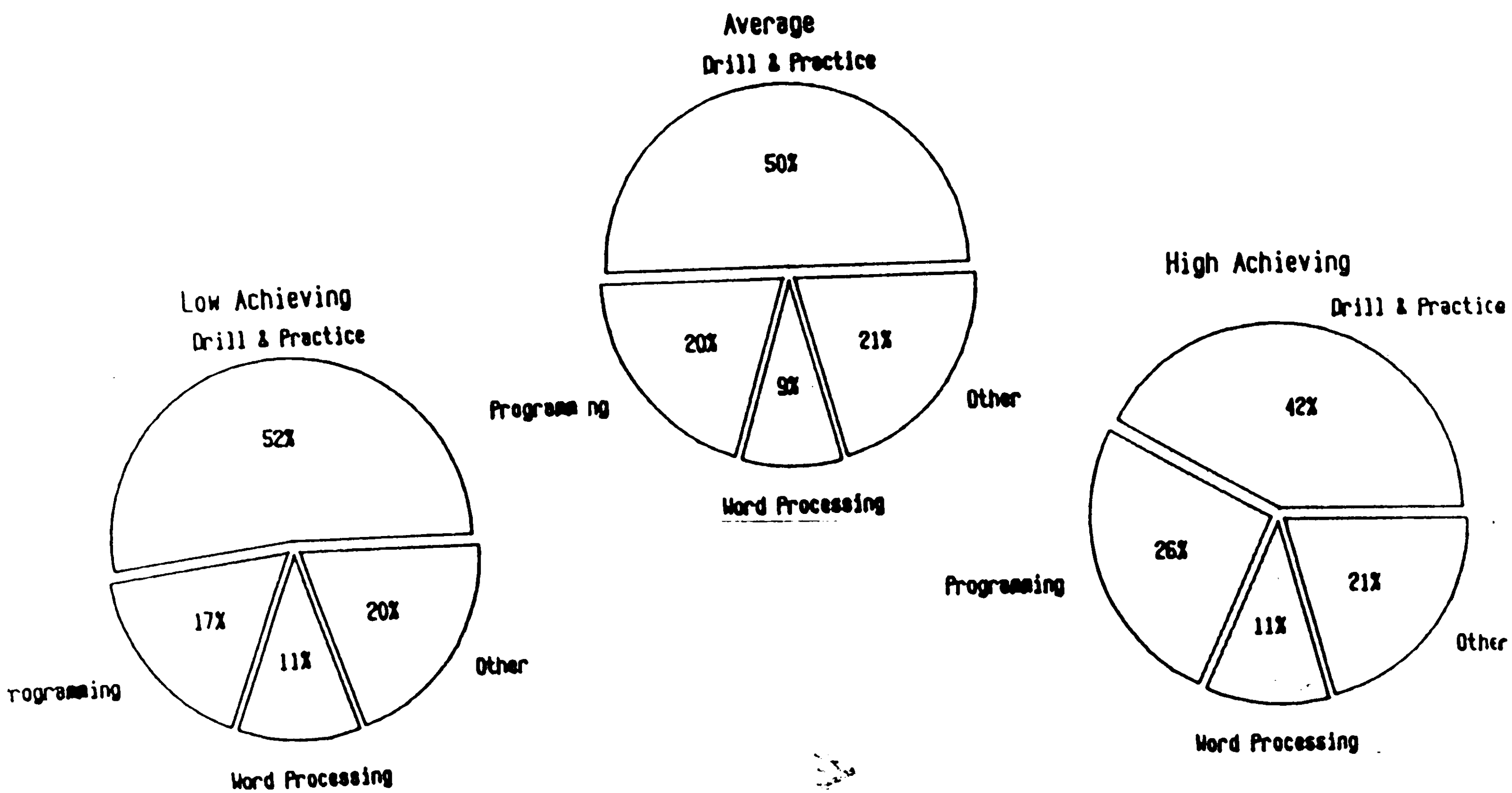
INSTRUCTIONAL APPLICATIONS OF COMPUTERS: VARI BY SOCIOECONOMIC STATUS OF STUDENT



SOURCE: 985 Nat ona + Survey of Instructional Uses of School Computers, Center for the Social Organizat f Schools, Johns Hopkins University.

FIGURE — o

INSTRUCTIONAL APPLICATIONS OF COMPUTERS: VARIAT BY ACHIEVEMENT LEVEL*



* SCHOOL-WIDE L TY MEASURE

SOURCE 1985 National Survey of Instructional Computers, Center for the Social Organization of Schools, Johns Hopkins University.

secondary school teachers; and in an average week, almost three times the proportion of teachers in the typical computer-using elementary school used computers as in the typical computer-using secondary school. These variances reflect basic differences in the educational programs of elementary and secondary schools, especially with respect to requisite sophistication in software.

An important question is whether teachers are adequately trained for instructional applications of computers.[9] While the evidence is still largely fragmentary, certain patterns warrant attention. Overall, about one-third of all U.S. teachers have had training —at least 10 hours — and over one-half of all computer-using teachers have had training. This is an important distinction, brought further into relief by comparison of elementary and high school teachers (see figure 1-11). Among the former, there are more who have had training in computers whether or not they make use of them in their classrooms; secondary school teachers, on the other hand, are less likely to have had training unless they are active computer-users. To the extent that elementary school children spend most of their time with regular teachers, it is probably to their advantage to have teachers with at least some general knowledge of computers; high school students, on the other hand, are better-served by computer-using teachers who have had specific training in subject areas. The basic distribution of training resources—limited as they have been — appears to have been guided to a large extent by educational needs.

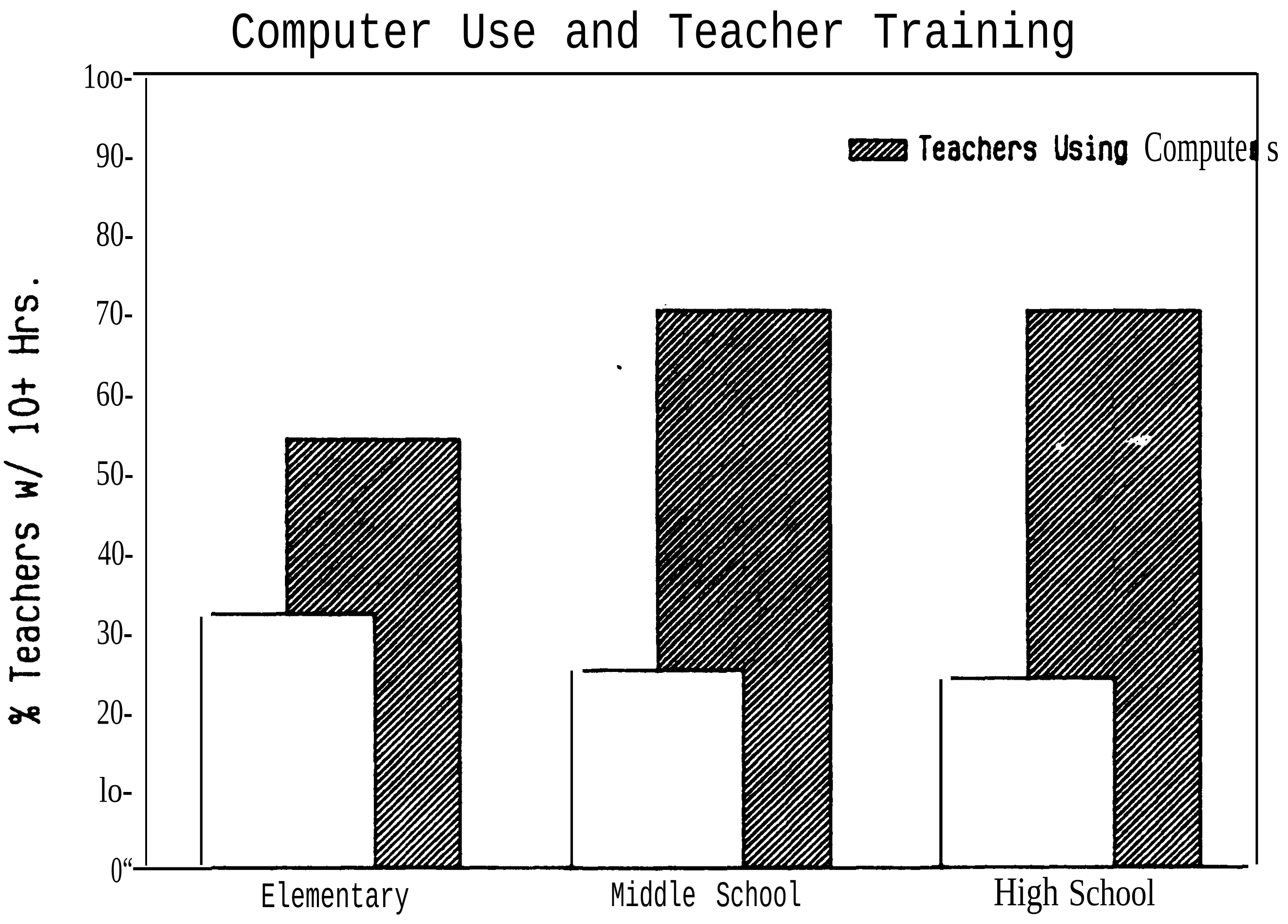
The issue of ongoing teacher training is the one most frequently mentioned by

---

8. 1986 data from the National Survey of ECIA Chapter 1 Schools, conducted by Westat Corporation for the U.S. Department of Education.

9. Many education researchers and policy analysts have stressed teacher training as perhaps the single most important ingredient to effective implementation of the new technologies. See, John Winkler, et al., The Rand Corporation, ‘Administrative Policies for Increasing the Use of Microcomputers," July 1986; Karen Sheingold, et al., Center for Children and Technology, Bank Street College of Education,"Preparing Urban Teachers for the Technological Future," Technical Report No. 36, 1985; and Brian Stecher, ‘Improving Computer Inservice Training Programs for Teachers," AEDS Journal, Winter 1984. Sherry Turkle, a sociologist who specializes inhuman interactions with machines, has argued for "socialization" of teachers, broadening the concept of training to include a wide range of behavioral and intellectual norms believed essential for effective integration of computers in education.

FIGURE 1-11



SOURCE: 1985 **National Survey** of **Instructional Uses** of **Schools,** Center for the Social Organization of Schools, Johns Hopkins University educational researchers, computer manufacturers, and software developers as the top priority to assure successful continuation of the implementation of computers in schools. The following questions should be included in legislative and regulatory deliberations:

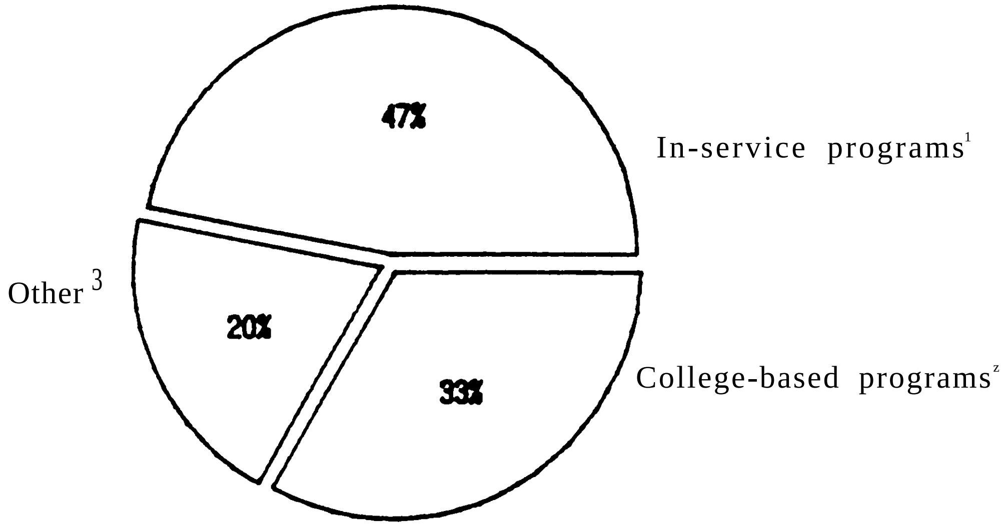
- Where do teachers receive their training? Current data suggest that as many as one-fifth of all teachers who receive training do so from nonschool sources, including manufacturers and vendors of computer equipment. (See figure l-12) While it is often quite valuable to have some involvement by computer dealers—just as textbook publishers often influence how teachers use particular books— this should not be the only means by which teachers learn to use computers for instruction.

- Does use of computers at home make better computer-using teachers? Among computer users, about 27 percent of elementary school teachers and about 40 percent of high school teachers have computers at home, compared to about 15 percent of all teachers. While teachers with their own computers may require less formal training in the technical aspects of computing, it would be a mistake to assume they do not require specific training in pedagogical applications. In addition, training policy should be sensitive to possibilities for in-home training and for sharing of hardware resources.

- Can students and teachers learn together? There is growing evidence — though largely anecdotal — that more and more students

FIGURE 1-12

Where Teachers Are Trained *



* Teachers with 10 or more hours of computer-related training.
1. In-service programs, typically offered on school premises.
2. In a college classroom for academic credit.
3. All other settings, including computer dealers.

SOURCE: 1985 National Survey of Instructional Uses of School computers, Center for Social Organization of Schools, Johns Hopkins University.

possess advanced computing skills, acquired from home, the video arcade, and even from school. Serious consideration should be given to the design of innovative arrangements through which students could share their knowledge with teachers. At the very least, such a system could help teachers with the rudimentary aspects of computing; perhaps more exciting is the possibility that the computer will become the vehicle for enhanced collaboration between students and teachers in many subject areas, which would have far-reaching consequences.

- Can teacher training and software development be integrated? Lessons from the higher education market, where professors have been granted released time from teaching to develop "courseware," might be applied to the K-12 environment in a fashion that facilitates both training in basic computer literacy and participation in software design. These arrangements should be sensitive to the protective instincts of administrators who are concerned that their best-trained teachers — in whom they have invested district or State resources — will be lured to nonteaching jobs that pay better.

EXPERIMENTAL RESULTS AND PERCEPTIONS: EFFECTS OF COMPUTERS IN EDUCATION

The 'bottom line" of an assessment of this sort might be expressed as the question most often asked by policymakers: "Do computers in the schools work?" The answer, based on limited research, seems to be "yes."[10]

10. The research results reported here are excerpted from D. Stern and G. Cox, "Assessing Cost Effectiveness of Computer-Based Technology in Public Elementary and Secondary Schools," OTA contractor reports, Jan. 8, 1987. The issue of cost

With respect to studies of computer-assisted instruction CAI, various outcomes have been considered. Using a technique known as "meta-analysis," developed in order to synthesize the results of many studies, one prominent researcher has concluded that "students have generally learned more in classes when they received help from computers." Another group of researchers, synthesizing numerous meta-analyses, found substantial learning gains associated with CAI.*

Research on the use of computers to develop so-called "higher order thinking skills" remains quite promising, but has not yet produced definitive results.[11] It should be noted that there is no universally accepted description or definition of what higher-order thinking skills are or how to assess students' competence in this area.

Relatively little attention has been paid to affective impacts of educational technology. From their meta-analysis of studies that have addressed this issue, James Kulick and co-workers conclude that "students' attitudes toward computers and toward instruction improved with the use of CAI."[12]

In addition to data that have emerged from experimental studies and related meta-analyses, an important source of information is perceptions of teachers and principals who have used computers in their schools. Becker's 1985 survey included a battery of questions that sought teachers' and principals' opinions about the degree to which computers made a difference for a wide range of educational and behavioral items (see figure 1-13). Key findings from this set of questions include the following:

- In all levels of schools (elementary, middle, and secondary), two areas

---

effectiveness, which must be distinguished from studies that concentrate on effects of computers independent of their costs, was the principal focus of Stern and Cox's paper, and will be addressed in a separate OTA document at a later date.

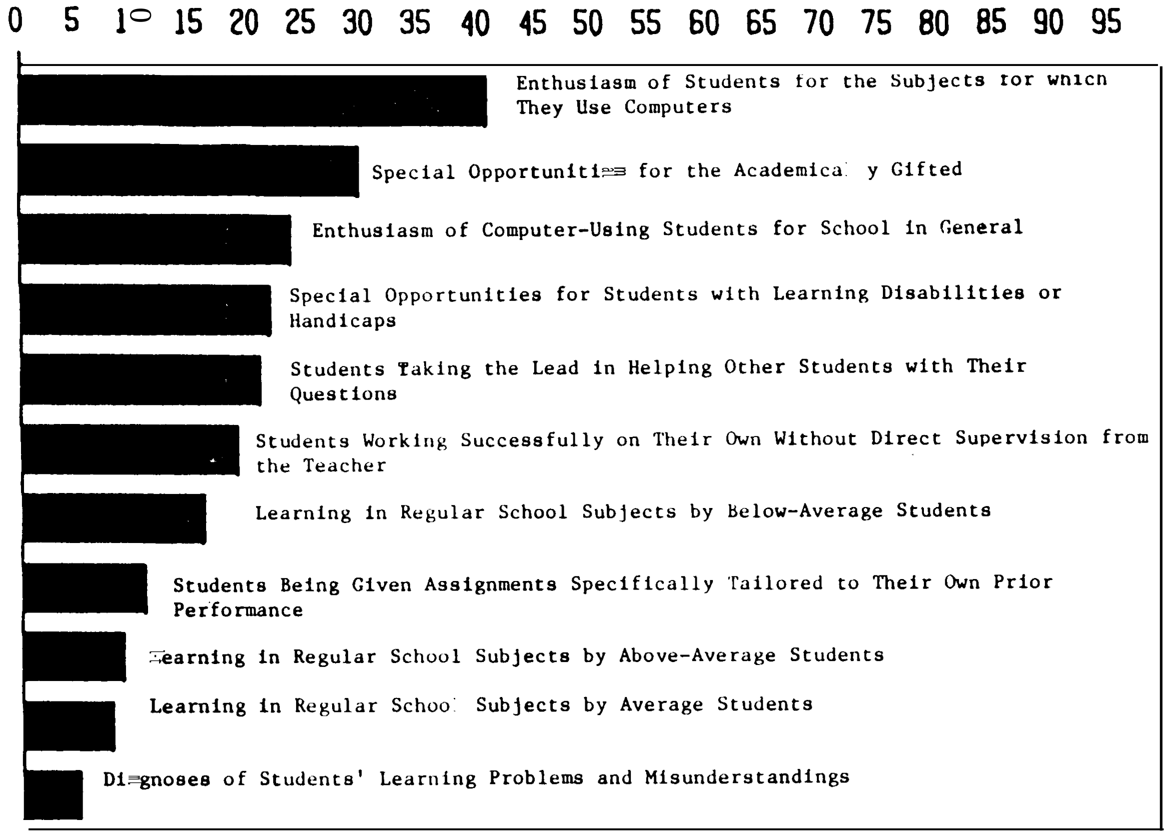
* For 11 sets of studies the "mean effect size" of CAI ranged from .26 to .56.

11. See Stanley Pogrow, Pedagogical and Curricular Techniques for Using Computers to Develop Cognitive and Social Skills: An Overview of the Techniques Used in the HOTS Program (Tucson AZ: Thinking With Computers, Inc., 1986).

12. Stern andCox, op. cit.

FIGURE 1-3

Perceived Effects of Computers



Percentage of primary computer-using teachers who reported that "as a result of computers, this is MUCH IMPROVED at our school" (Respondents could have chosen "somewhat improved" or "little changed" or "negatively affected")
SOURCE: 1985 National Survey of Instructional Uses of Schoo[l] Center for Social Organization Schoo[l]s Johns Hopkins University.

were seen to have been most significantly improved by a large percentage of respondent-s: enthusiasm for subjects in which the computer was used — not to be confused with computer-related subjects such as programming— and the development of special learning opportunities for academically gifted children.

- Many teachers report that computers offered new and challenging opportunities for academically gifted children who might otherwise have been restricted to conventional curriculum materials. However, only 9 percent of the teachers felt that of regular subjects by this group was greatly improved.

- Learning of regular subjects by below-average students was seen to have improved substantially by more respondents than was learning by average and above-average students.

- Less than 1 percent of computer-using teachers felt that computers had a negative impact on any aspect included in the n-part question.

- The more time students spend on computer programming, the less significant are their gains in most areas, particularly in learning of regular subjects. More time spent on word processing, on the other hand, is correlated with greater perceived educational gain.

- According to their teachers and principals, students working with computers improve their independent working skills, which is expected;

but their ability to cooperate with peers is perceived to improve significantly by an even greater percentage of respondents, a result that is reassuring in the light of oft-expressed concerns about computers discouraging human communication and interaction.

NOTES ON DATA SOURCES AND METHODOLOGY

A. Market Data Retrieval, Inc., Shelton, Connecticut

This company has conducted a telephone survey of public school districts each summer for many years. The survey, conducted from July to September, gathers data on school and district enrollments and grade spans, school openings and closings, and other information such as address and telephone changes. Every school district is contacted. Mail surveys, conducted throughout the Fall, are used to supplement the data acquired by telephone.

Since all districts are contacted, the number of schools reported as computer-users is not a projection based on a sample, but rather the total. However, not all districts are able to supply information on the quantity of computers in each school. Data on computer access, therefore, are based on the portion of schools for which districts were able to provide complete data.

The measure of poverty is based on U.S. Census Bureau estimates of the percent of families below the Federal poverty line in the school district. Note that all schools within a given district do not necessarily have the same level of poverty.

B. 1985 National Survey of Instructional Uses of School Computers, Johns Hopkins University, Center for Social Organization of Schools, Baltimore, Maryland; Henry Jay Becker, project director.

The principal activity of this project was to design, conduct, and prepare for analysis a major national survey of the instructional uses of computers in American elementary and secondary schools. The survey was fielded between January and June of 1985, and the data were prepared for computer-based analysis from then until November. Six survey instruments were developed in order to gain as rich a compilation of information from schools and their personnel as possible. The sampling universe included 100,625 schools in the United States, all public and nonpublic schools enrolling nonadult students in any of the grades K-12. The sample universe was developed by Quality Education Data (QED), during the summer and fall of 1984 (see also below). Following a stratification plan designed to afford a statistically accurate sample of schools of varying grade span, student age, and other factors, 2,361 schools were sampled from the universe list. Response rates varied by survey instrument from 88 percent to 97 percent, including telephone subsample follows-ups. A total of 10,023 survey instruments comprise the database used for the study. For more complete details ensampling methodology and weighting, see "Final Report: The Second National Survey of Instructional Uses of School Computers," NIE-G-83-0002, U.S. Department of Education.

c. Quality Education Data, Inc. (QED), Denver, Colorado.

QED is a research company that has been gathering information on U.S. elementary and secondary schools for five years. The database contains more than 100 variables, and covers all educational institutions (including colleges, libraries, prisons and nonpublic schools. Data are collected by telephone surveys conducted from May through September each year.

Lifestyle Selector. A Washington-based demographics firm, Claritas, Inc., has developed 40 ‘lifestyle clusters,˜ each of which describes a set of American neighborhoods in terms that capture salient social, economic, demographic, and educational qualities. For example, cluster number 28, called "Blue Blood Estates,” is described as "America's wealthiest socio-economic neighborhoods, populated by super-upper established managers, professionals, and heirs to ‘old money,’ accustomed to privilege and living in luxurious surrounds. One in ten millionaires can be found in cluster 28, and there is a considerable drop from these heights to the next level of affluence.n

From these clusters, a set of 10 “lifestyle selectors" was created, each of which includes a particular subset of the 40 clusters. For example, “educated elite,” which is discussed in this OTA report, includes “blue blood estates” “furs and station wagons” “money and brains,” “pools and patios,” and “God’s country." “Farmers and rustics” and the “urban melting pot” selectors, also noted in the OTA discussion, comprise different sets of the Claritas clusters. The 10 selectors were then assigned to the QED database, on a per-school basis. Each school can be characterized by one of these indicators.

CHAPTER 2

CHAPTER 1 AND THE USE OF EDUCATIONAL TECHNOLOGY

CHAPTER 2

CHAPTER 1 AND THE USE OF EDUCATIONAL TECHNOLOGY

INTRODUCTION

Chapter 1 of the Education Consolidation Improvement Act of 1981 (ECIA) is the largest federally funded elementary and secondary education program.* The primary goal of the program is to provide supplemental educational and related services to educationally disadvantaged children who attend public or private schools in low-income areas.** [1] Approximately 4.8 million children receive Chapter 1 services. Seventy-seven percent of these students attend elementary schools (preschool through grade 6). At both elementary and secondary levels, instruction is provided in reading, mathematics, and language arts.

Most of the provisions of the Chapter 1 legislation were originally contained in Title I of the Elementary and Secondary Education Act, which was passed by Congress on April 11, 1965, and amended several times thereafter. The program was established because Congress recognized that educationally disadvantaged children who attend schools in low-income areas have special educational needs which cannot be met by regular education programs, but the State and local education agencies (SEAs and LEAs)

---

* Of $17.8 billion appropriated to Federal education programs in FY86, approximately $3.5 billion went to Chapter 1.

** Children who are eligible for services attend schools in areas that are considered to below-income relative to the average income of the local education agency.

1. Local education agencies receive Chapter 1 funds through the basic grant program. State education agencies are responsible for administering Chapter 1 programs for handicapped, migrant, neglected, or delinquent children. The State agencies also receive administrative grants, which are ". . . equal to the greater of 1 percent of the State's Chapter 1 allocation or $225,000 per State, to help them meet their program responsibilities." Wayne Riddle, "Education For Disadvantaged Students: Federal Aid," Issue Brief IB81142 (Washington, DC: U.S. Congress, Congressional Research Service, Education and Public Welfare Division, Apr. 10, 1986).

that serve such areas may not have the financial resources to provide' these services. Congress specified that funds be used only to provide compensatory and/or remedial instruction: the services these children receive must "supplement, but not supplant" their regular educational program.[2]

In 1981, Congress restructured Title I to reduce administrative burdens of reporting and regulatory requirements and "to free the schools of unnecessary Federal supervision, direction and control."[3] The new provisions of the Chapter 1 legislation gave States more freedom to design and administer programs. Further flexibility in carrying out programs was legislated in 1983, when technical amendments to the law were passed.

A recent U.S. Supreme Court decision significantly affects some Chapter 1 program services. On July 1, 1985, the Court, in the case of Aguilar v. Felton, ruled unconstitutional the method of providing Chapter 1 services to eligible children who attend nonpublic sectarian schools (approximately 4 percent of all Chapter 1 students). Approximately 78 percent of these children received instruction from public school teachers on the premises of the nonpublic sectarian schools. According to the decision, this method observing students led to excessive entanglement of Church and State. As a result, LEAs now provide Chapter 1 services to nonpublic sectarian students, where

2. "A State educational agency or other State agency in operating its State level programs or a local educational agency may use funds received under this chapter only so as to supplement, and to the extent practical, increase the level of funds that would, in the absence of such Federal funds, be made available from non-Federal sources for the education of pupils participating in programs and projects assisted under this chapter, and in no case may such funds be so used as to supplant such funds from such non-Federal sources." Public Law 89-10.

3. "The Congress . . . finds that Federal assistance [to meet the special educational needs of disadvantaged children] will be more effective if education officials, principals, teachers, and supporting personnel are freed from overly prescriptive regulations and administrative burdens which are not necessary for fiscal accountability and make no contribution to the instructional program." Public Law 89-10.

feasible, in one or more of the following ways: in public schools, at neutral sites, in mobile vans, or through the use of audio or visual broadcasts and/or computer assisted instruction which allow LEAs to deliver structured services without requiring the presence of public school staff n the premises of the non public sectarian school.[4]

EARLY USE OF TECHNOLOGY IN CHAPTER 1

Since 1965, schools have used some of their Title land Chapter l funds to purchase technology. In the 1960s, hardware on "the cutting edge" included overhead projectors, tape recorders, television sets, tachistoscopes (devices similar to film projectors that helped build students' vocabulary), and reading machines, which magnetically "read" vocabulary and mathematics flash cards. The infusion of Federal funds allowed schools to buy the new equipment, but little effort was expended to find instructive and effective ways to use it. Thus, much of the equipment sat idle in classrooms or was left in boxes and never unpacked.[5]

The first CAI programs entered the Nation's schools about the same time as teaching machines. For example, in 1965, four public school systems, including New York City and Philadelphia, implemented CAI systems.[6] Using mainframe computers with terminals, the CAI programs were designed to provide reading and mathematics instruction to elementary school students.

---

4. For more information, see David Ackerman and Wayne Riddle, "The Implications of Aguilar v. Felton for The Provision of Title l/Chapter 1 Assistance to Nonpublic Schoolchildren," (Washington, DC: U.S. Congress, Congressional Research Service, Aug.30, 1985).
5. For more information see National Advisory Council on the Education of Disadvantaged Children, Second Report (Washington, DC: U.S. Government Printing Office, 1966). Washington Research Project of the Southern Center for Studiesin Public Policy and the NAACP Legal Defense and Education Fund, Inc., Title Iof ESEA: Is It Helping Poor Children? (Washington, DC: 1969).
6. For more information see Beverly Hunter, 'Computer Literacy: 1949-1979," Computer Literacy, Robert J. Seidel, et al., (eds.) (New York: Academic Press, 1982), pp. 33-47. See also, Carol Hargan and Beverly Hunter, Instructional Computing: Ten Case Studies (Alexandria, VA: Human Resources Research Organization, 1978).

Federal funds not only supported the early research and development (R&D) of these programs, but also their implementation in schools serving educationally disadvantaged students. A 1982 OTA report found that R&D projects funded by the National Science Foundation and the Office of Education had a major impact on the state of the art in computer-based learning and teaching. The study also found that "... the focus of the Elementary and Secondary Education Act on the disadvantaged resulted in the development and implementation of high-technology systems that are effective in providing such students with basic skills."[7]

One of these early CAI systems was developed by the Computer Curriculum Corporation (CCC). It has been evaluated extensively with a wide variety of students, including disadvantaged students. A 5-year longitudinal study determined that the CCC drill and practice computer programs could improve the performance of compensatory education students in reading, mathematics, and language arts. When compared to a control group, students using the CAI materials made significant gains. Data from this study also indicated that the achievement gains could be maintained (even over summer vacations) and could be expected to increase steadily over several years of CAI participation. In addition to academic gains, students' interest and motivation increased and incidents of vandalism and truancy decreased.[8]

The effectiveness of some early CAI programs lent credence to the idea of using powerful computing devices to provide instruction. With the advent of microcomputers, this idea spread rapidly throughout the Nation% schools. According to data from a

---

7. U.S. Congress, Office of Technology Assessment, Information Technology and Its Impact on American Education (Washington, DC: U.S. Government Printing Office, November 1982), p. 134.

8. Ibid. For more information on this evaluation see M. Ragosta, et al., Computer-Assisted Instruction and Compensatory Education: The ETS/LAUSD Study, The Final Report, #19 (Princeton, NJ: 1982); D. Jamison, et al., "The Effectiveness of Alternative Instructional Media: A Survey," Reviewof Educational Research, vol. 44, No. 1, 1974; and M.D. Roblyer, Measuring the Impact of Computers in Instruction: A Non-Technical Review of Research for Educators (Washington, DC: Association for Educational Data Systems, 1985).

National Center for Education Statistics (NC ES) Fast Response Survey, the number of microcomputers in schools "slightly more than doubled" from November 1980 to May 1982.[9] Reports from a variety of sources cite five reasons for this "microcomputer revolution in America's schools:",[10]

- Computer advocates within and outside of school districts who saw computers as a way to revolutionize education persuaded district administrators to consider adopting computer technology.

- Pressure from parents who felt that their children must learn about computers to be successful was exerted on local and State education policy makers.

- Administrators saw that other schools were buying microcomputers, and they decided to "jump on the bandwagon."

- The educational reform movement which swept the country in the early 1980's emphasized student achievement and productivity. Computers were viewed as a means to increase both achievement and productivity.

- The result of the reform movement, in many cases, was new regulations. New demands were placed on teachers and administrators to manage

---

9. U.S. Department of Education, Office of Educational Research and Improvement, National Center for Education Statistics, Instructional Uses of Computers in Public Schools, Fast Response Survey System Report No. 14 (Washington, DC: U.S. Government Printing Office, Spring 1982), p. 2.
10. For more information see "Appendix A — Case Studies: Applications of Information Technologies" in U.S. Congress, op. cit.; and also see Robert K. Yin and J. Lynne White, Microcomputer Implementation in Schools (Washington, DC: Cosmos Corp., March 1984).

instruction. Computers, especially computer managed instruction programs, were viewed as a way to help meet those demands.

The factors which led to the adoption of computers in schools inevitably influenced the adoption of computers in Chapter 1 programs. A 1983 study for the Department of Education found that '... computers play a small but growing role in Chapter 1 instruction." The study reported that "on average" Chapter 1 students had the same access to computers as non-Chapter 1 students. However, actual computer use varied in significant ways. Chapter 1 students were more likely to use computers for remediation and less likely to use them for enrichment than were their non-Chapter 1 peers.[11]

THE SPECIAL CASE OF AGUILAR V. FELTON

One month after the Supreme Court rendered its decision in the case of Aguilar v. Felton, the U.S. Department of Education issued the first set of nonregulatory guidance to SEAS on how to comply with the decision. These guidelines did not specifically mention computers, but said only that "a private school child [can] take Chapter 1 instructional materials onto private school premises for his or her use as part of the child% Chapter 1 program."[12] A second set of Department guidelines, issued 1 year later, suggested ways in which CAI might be able to "withstand judicial scrutiny" and be used as a remedy to the decision. To date, there have been no court cases in which the legality of using CAI as a remedy has been tested.

11. For more information see Elizabeth R. Reisner, The Use of Computers In instruction Supported Under Chapter 1 of the Education Consolidation and Improvement Act (Washington, DC: U.S. Department of Education, September 1983).
12. U.S. Department of Education, Guidance on Aguilar v. Felton and Chapter 1 of the Education Consolidation and improvement Act Questions and Answers (Washington, DC: August 1985), p. 17.

The use of CAI as a remedy to Aguilar v. Felton raises important legal issues. CAI equipment placed on the premises of the religiously affiliated private school, under certain conditions, could lead to excessive entanglement of Church and State.[13] The 1986 Department guidelines list the following five criteria for placing the CAI system on the premises of the nonpublic sectarian school:[14]

> As with all Chapter 1 programs serving private school children, the CAI program must be under the LEA's direction and control. On-site review by public school officials must be limited, however, to such things as the installation, repair, inventory, and maintenance of equipment.
>
> Private school personnel may be present in CAI rooms to perform limited noninstructional functions such as to maintain order, to assist children with equipment operations (such as turning the equipment on and off, demonstrating the use of the computers, and accessing Chapter 1 programs), and to assist with the installation, repair, inventory and maintenance of the equipment.
>
> Neither public nor private school personnel may assist the students with instruction in the CAI room. Public school personnel may, however, assist by providing instruction through computer messages, by telephone, or by television.
>
> Access to the computer equipment and the rest of the program must be limited to Chapter 1 eligible children.
>
> Equipment purchased with Chapter 1 funds may not be used for other than Chapter 1 purposes.

To meet this set of requirements, some school districts have purchased or leased distributed CAI systems. These systems comprise a mainframe or host computer located at an LEA-owned site that are linked to terminals located at the religiously affiliated private schools. Terminals connect to the mainframe computer via a telecommunications network of dedicated cables, regular telephone lines, or microwave link(s).

---

13. The Supreme Court has previously examined the constitutionality of public subsidies of the cost of nonpublic sectarian education, especially the cost of instructional services. See Meek v. Pittenger, 421 U.S. 439 (1975), and Wolman v. Walter, 433 U.S. 229 (1977); and Also, see Ackerman and Riddle, op. cit.

14. U.S. Department of Education, Additional Guidance on Aguilar v. Felton, and Chapter 1 of the Education Consolidation and Improvement Act (ECIA) Questions and Answers (Washington, DC: June 1986), pp. 8-9.

There are some advantages to using these distributed CAI systems to serve students who attend nonpublic sectarian schools. First; it is possible to track and record student performance with the management component built into the system software. Thus, a Chapter 1 teacher can monitor students' progress and the LEA can send a print-out of the students' work to their regular classroom teachers. This may enhance coordination between the Chapter 1 program and the private school. Second, because only eligible students are given a password to access the CAI program, LEAs do not have to be concerned about compliance with Federal regulations regarding the use of Chapter 1 funds. Third, neither teachers nor students can modify the CAI programs. Thus, LEAs do not have to take extra steps to prevent sectarian schools from diverting the technology for religious purposes.

There are also several disadvantages to using CAI as a remedy. If students are using "dumb" terminals, they are likely to encounter delays between the time they enter an answer into the computer and the time the computer responds to it. * The time it takes to process messages has at least two effects on the instructional process. First, students may lose interest in the subject matter if they have to wait too long for a response. The computer is no longer providing them with instant feedback, a feature that is often said to be the key to the technology's ability to help motivate disadvantaged students. Second, because graphics require large amounts of data to be sent from a mainframe to a terminal, elaborate graphics are generally not found in distributed systems. Graphics capabilities are another feature of the computer technology that make it so appealing as an educational tool.

While delays can be prevented and more complex graphics can be displayed if districts purchase "smart" terminals, which are essentially stand alone computers that

* This is because the student% message must travel from the terminal over cables, telephone lines, or microwaves to an input buffer in the mainframe. The message remains in that buffer until the mainframe is ready to process it. Messages are processed on a first-come, first-serve basis. After the message is processed, it is sent to an output buffer and then back to the student% terminal.

allow entire programs to be downloaded from the mainframe, there are other limitations to these CAI systems. For example, software programs can be changed only by the vendor. This limits the inherent flexibility of the computers a multipurpose tool.

The costs of distributed CAI systems maybe prohibitive for many LEAs. Districts must either purchase or lease the following equipment and services: hardware, which includes the mainframe/host computer, dumb or smart terminals, modems for communication between terminals and a mainframe; software; a telecommunications link, the cost of which will vary depending upon the type of linkage; the installation of the hardware, software, and telecommunications links; hardware and software maintenance; and training — for both the public school teacher at the LEA site and for "monitors" on the premises of the religiously affiliated private school. * The costs for just the hardware (mainframe, terminals, and modems) and software range from $80,000 to $185,000.**

Another disadvantage of this approach is that Chapter 1 teachers cannot easily communicate with the students at these sites. Districts can purchase electronic or telecommunications systems to facilitate that communication, such as electronic mail, telephone hook-ups, or bi-directional television, at an additional expense. Without these peripheral devices for communication, the Department acknowledges that it is not clear if CAI alone will meet the equitability requirements of Chapter 1:

> When both public and private school children are receiving the same CAI service, the equitable services requirement of Chapter 1 is met. When CAI is being provided to private school children while public school children are receiving direct instruction from a teacher, the question of equitability is more difficult.[15]

---

* Training costs should be minimal since neither public nor nonpublic school personnel can provide instruction to students who attend religiously affiliated private schools on the premises of those schools.

** One State is considering placing a mainframe in its cooperative computer center. Districts throughout this State would have access to the system. The fees for this service would be prorated. According to the coordinator, such a cooperative system would give this State the highest proportion of nonpublic students served in the Nation.

15* According to the Departmentfs nonregulatory guidance, "this may be especially true in a year after the computers were purchased since, after the initial purchase of

The reason the question of equitability is more difficult is that private school personnel are not allowed to assist students with instruction in the CAI classroom in the private school building. Because the functions that nonpublic sectarian staff can perform are so limited, the quality of services nonpublic school students receive may not be comparable to those given to public school students.[16]

PRESENT USE OF COMPUTERS IN CHAPTER1

A Statistical Profile[17]

While not all Chapter 1 programs use computers, approximately 60 percent of public school Chapter 1 teachers report that they use computers to teach their Chapter 1 students. (See Figure 2-1) Of the more than 3 million Chapter 1 elementary school students in the nation, about 2.4 million (71.6 percent) have Chapter 1 teachers who use

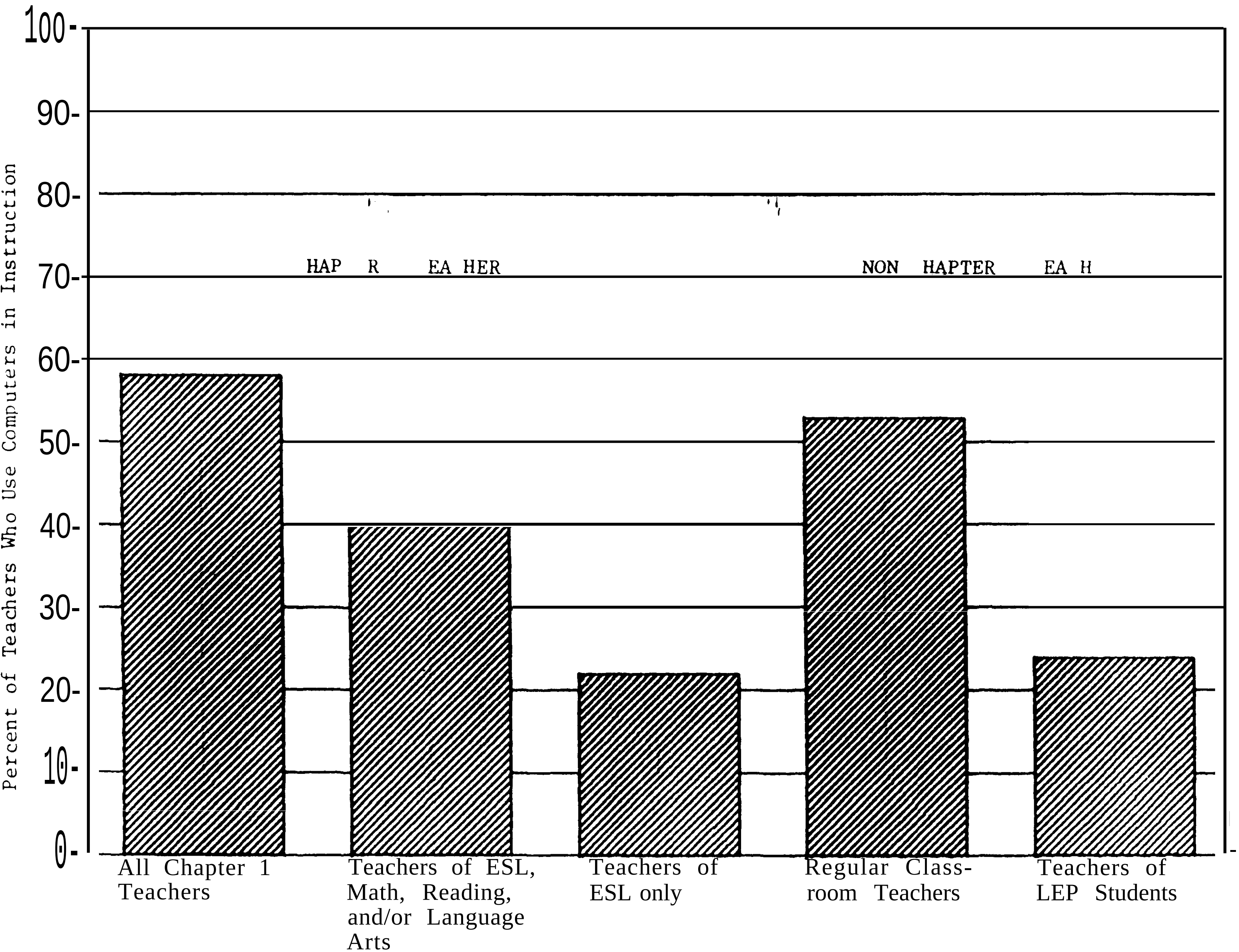
---

equipment, CAI normally provides services at a cost less than the typical Chapter 1 program." However, the Department permits LEAs to spread out the cost of purchasing a CAI system over a period of years "for the purpose of meeting the equitable cost requirement," U.S. Department of Education, Additional Guidance-on Aguilar v. Felton, and Chapter 1 of the Education Consolidation and Improvement Act (ECIA) Questions and Answers, op. cit., p. 10.

16. The Department% guidelines state, "if the CAI alone does not provide this equity, the LEA may make up the difference by offering additional services, such as tutorial centers of appropriate summer school programs. Of course, private school children may choose to participate in only a portion of the services offered, and the offer may still be considered equitable," U.S. Department of Education, Additional Guidance on Aguilar v. Felton, and Chapter 1 of the Education Consolidation and Improvement Act (ECIA) Questions and Answers, op. cit., p. 11.

17. The analysis in this section is based on two principal sources of data: (1) original data from the 1986 National Surveyof ECIA Chapter 1 Schools conducted by the Westat Corporation for the U.S. Department of Education's 1986 National Assessment of Chapter 1, and (2) original data from the 1985 National Survey conducted by the Center for the Social Organization of Schools at Johns Hopkins University, under the directionof Henry Jay Becker, as well as summaries found in the "Instructional Uses of School Computers" newsletters, issues 1-3, 1986.

FIGURE 2-1. --TEACHERS* USING COMPUTERS IN INSTRUCTION

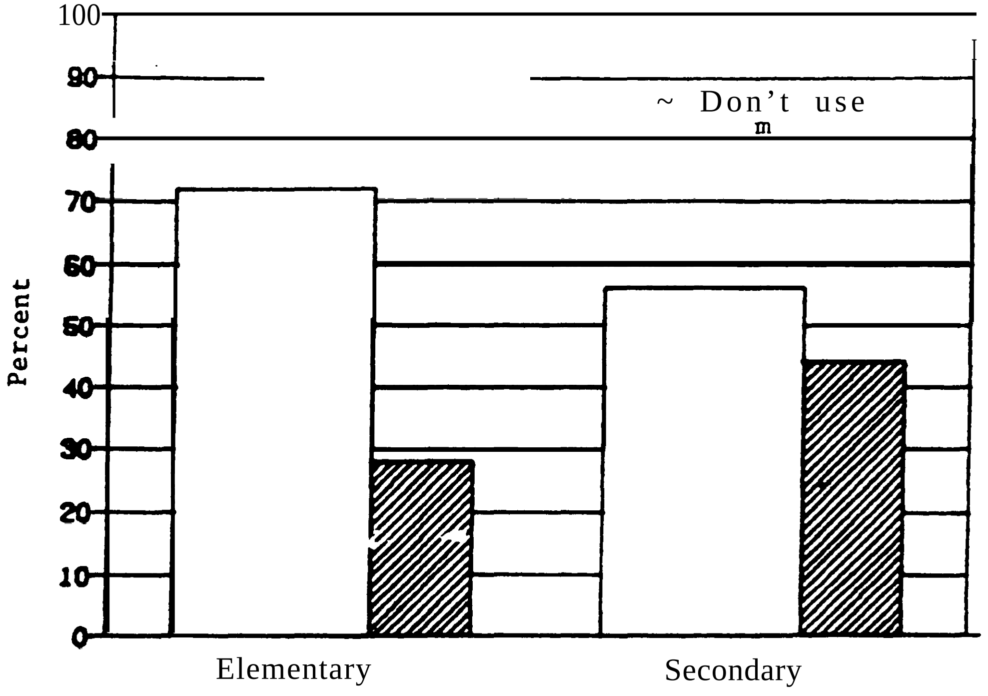


*In schools receiving chapter 1, State, or other compensatory education or special education services.

SOURCE: Westat Corp., National Survey of ECIA Chapter 1 Schools, 1986

FIGURE 2-2”

COMPUTER USE BY CHAPTER 1 STUDENTS



A.

SOURCE: Westat Corporation, National Survey of ECIA Chapter 1 Schools, 1986.

computers. Of some 960,000 Chapter 1 middle/high school students nationwide, 540,000 (56.1 percent) have Chapter 1 teachers who use computers. (See Figure 2-2) The degree to which Chapter 1 teachers use computers depends upon a number of factors:

Concentration of Poverty

Chapter 1 teachers working in high schools where more than 40 percent of the students are eligible for free or reduced price lunches are less likely to use computers than teachers working in other high schools. In elementary schools, however, the use of computers by Chapter 1 teachers increases with the school% concentration of poor students; but in the very poorest elementary schools — where more than 75 percent of the children are eligible for free lunches — the percentage of Chapter 1 teachers using computers is lower than in other schools. (See Figure 2-3)

Subject Matter

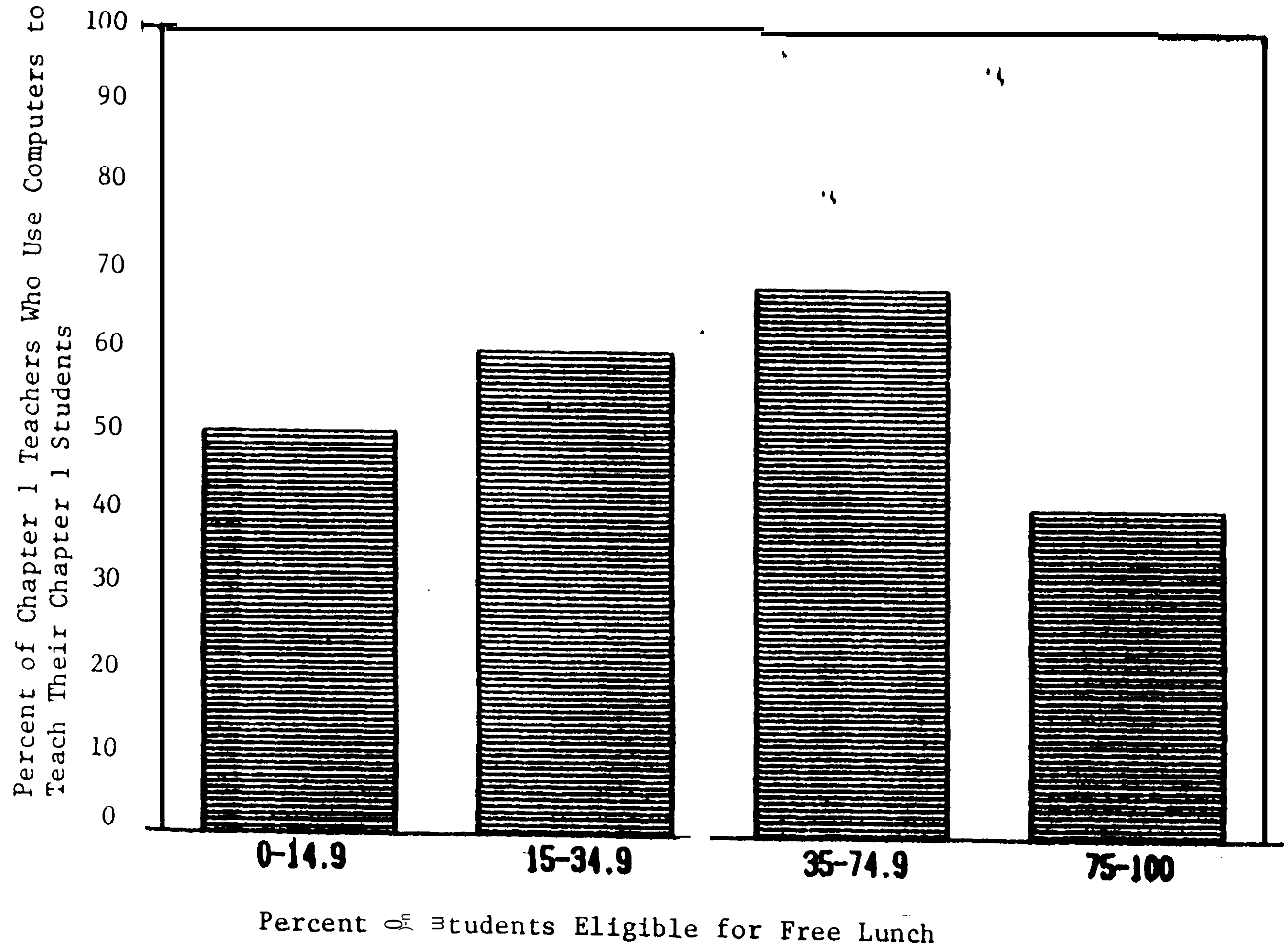
Chapter 1 teachers of reading, language arts, and mathematics are about equally likely to use computers with their students: 62 percent of those who teach mathematics, 59 percent of those who teach reading, and 57 percent of those who teach language arts use computers. However, only 40 percent of Chapter 1 teachers who teach English as a second language (ESL) along with other subjects use computers, and only 22 percent of those who teach ESL exclusively use them.

Academic Achievement

Students who receive Chapter 1 services are usually performing below grade level. There is a slight difference in the likelihood of computer use in mathematics and reading that appears to be related to the achievement level of the Chapter 1 students. Teachers who use computers have a higher proportion of students who score below the 50th percentile in these subjects than teachers who do not use computers. (See Figure 2-4)

FIGURE

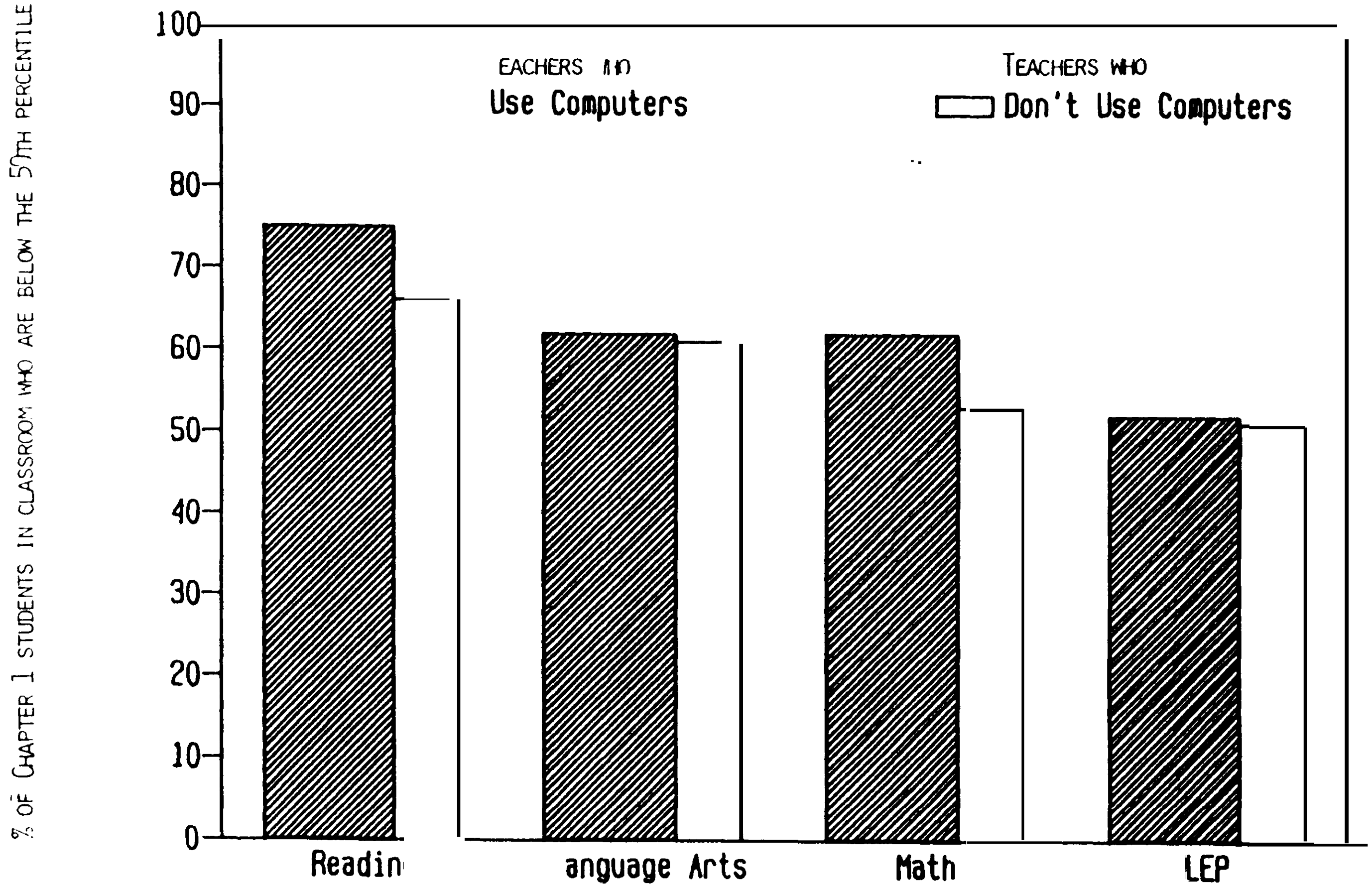
CHAPTER 1: COMPUTER USE AND ELEMENTARY SCHOOL POVERTY LEVEL



SOURCE: Westat Corporation, National Survey of ECIA Chapter 1 Schools, 1986

FIGURE 2-4

COMPUTER USE BY CHAPTER 1 TEACHERS: VARIATIONS BY ABILITY LEVEL OF CHAPTER 1 STUDENTS IN THEIR CLASSES



SOURCE: WESTAT CORPORATION, SURVEY OF ECIA CHAPTER SCHOOLS, 1986

This finding may be related to the finding that teachers believed that computers benefit below average students more than average or above average students. This perception was shared by a higher percentage of teachers as the concentration of Chapter 1 students in the school increased. Both Chapter 1 and non-Chapter 1 teachers believe computer use raises students' enthusiasm for subjects in which the computer is used.

Urbanicity

Chapter 1 teachers who teach in rural schools are more likely to use computers than their counterparts in urban schools. Sixty-one percent of Chapter 1 teachers in rural schools use computers, while only 53 percent of Chapter 1 teachers in urban schools use them. Perhaps Chapter 1 teachers in rural areas use computers more because they have more access to them, since both classes and schools tend to be smaller in rural districts than in urban areas.

OTA Survey of Chapter I Directors

The statistical data provide an important overview of the some of the factors that influence computer use in Chapter 1 programs. OTA also surveyed State Chapter 1 directors and interviewed local project officials to gain a fuller picture.

Because State coordinators approve LEA requests for the purchases of instructional equipment with Chapter 1 funds, their views about the use of computers in the program can be very informative. To gain abetter understanding of those views, OTA sent a one-page survey questionnaire in September 1986 to all 50 State Chapter 1 coordinators and the coordinator for the District of Columbia.* In addition, OTA staff contacted each coordinator in December 1986 for the purpose of clarifying or expanding information provided in the questionnaire and to pose additional questions about the use of

---

* In reporting responses to the survey, the term State is used generically to categorize the 50 States and the District of Columbia.

computers. The response rate to the mail and telephone surveys was 100 percent. In exchange for their replies, the State coordinators were granted complete confidentiality. The results of the survey appear below.**

The Amount of Money Spent on Hardware and Software

Every State coordinator reports that Chapter 1 funds have been used to purchase and/or lease computer hardware and software since 1980. However, not every coordinator knows how much money was spent, because States are not required to collect and report information about the use of Chapter 1 funds for the purchase of computers. In fact, several State coordinators contacted local district Chapter 1 directors to answer the OTA questionnaire.

Even though State coordinators provided information on expenditures, many described their responses as "very rough estimates." While it is important to remember these qualifications, the figures can provide a sense of the size of the expenditures for computer hardware and software. Thirty-nine coordinators provided estimates of the amount spent to purchase and/or lease computer hardware and software for Chapter 1 programs from 1980 to 1985. Over this 5-year period, these 39 States spent approximately $89 million. This figure insignificant: it indicates that there is already a market for hardware and software in compensatory education programs.

Some vendors and publishers are aware of this market and are actively pursuing it. Three State coordinators mentioned that they feel pressure from vendors to purchase computers. One coordinator observed: "Right now, we have a bunch of companies who

** It is important to point out that these views may not coincide with the views of local district Chapter 1 educators. The U.S. Department of Education National Assessment of Chapter 1 is gathering extensive information from interviews with district Chapter 1 coordinators and teachers and from case studies of local programs; thus it can be expected that local views will be represented.

In the course of the OTA State survey, several respondents attached information about computer use in Chapter 1 from local district reports in their State or provided contacts at the local level. Thus OTA staff were able to gain a fuller understanding of actual computer use.

are trying to sell products to educators. Educators should be driving this whole marriage between education and technology. They should be saying, 'here are some problems that need to be solved.' [Now], we have people [vendors] who are dumping products they couldn't sell to businesses on schools. Yet we're one of the largest potential markets.~

Few coordinators provided details about spending patterns in the last 5 years. But from their comments, it appears that spending patterns in Chapter 1 programs for computer hardware and software reflect national trends: between spring 1983 and spring 1985, the number of computers in use in schools jumped from about 250,000 to over one rnillion.[18]

From data provided by 36 States (including 34 of the aforementioned 39 States), OTA estimates that States now spend, on average, 1.6 percent of their Chapter 1 budget to purchase and/or lease computers. The percentage of each State's budget spent on computer technology ranges from 0.02 percent to 9.5 percent. In addition, two State coordinators who did not provide budget figures, indicated that their States have a policy which limits the amount of Chapter 1 funds for computer purchases to 2 percent and 5 percent, respectively.

According to data provided by 37 States, Chapter 1 funds will continue to be used for the purchase of computer hardware and software in the 1986/1987 school year. From the various State figures and estimates provided, OTA projects that 37 States will spend approximately $21 million in the 1986/1987 school year. However, it should be noted that 17 of those 37 States plan to spend <u>less money</u> on the technology in the 1986/1987 school year than they have in the past, while ten States plan to spend <u>more money</u>, and 10 States plan to spend the <u>same amount</u> of money. Two coordinators reported that some of the monies spent on computers would be used to purchase systems that would serve as a remedy to the <u>Aguilar</u> v. <u>Felton</u> decision. One of these coordinators cited this

18. For more information see Henry J. Becker, <u>[instructional Uses of School -Computers</u>, Reports from the 1985 National Survey, (Baltimore, MD: Johns Hopkins University, Issue No. 1, June 1986), p. 1.

particular purchase as the reason for the increase in the amount of money spent on computers this year.

The Uses of Computers

In Chapter 1 programs, computers have been purchased for administrative purposes, instructional purposes, or both. In 44 States, Chapter 1 programs are using computers for both instructional and administrative purposes. Of the seven States which reported using computers solely for instructional purposes, five did, in fact, reference ways in which computers are used for administrative purposes. There is good reason for this overlap.* Many administrative uses are linked directly to the instructional program in the actual provision of services to students. Computers are used to help teachers diagnose and develop individual plans for students, to keep records, and to track the progress of those students. Coordinators believe that the technology allows teachers to spend more time providing direct instruction to students. Notes one coordinator: "... teachers don't have to spend time on pencil and paperwork [anymore]."

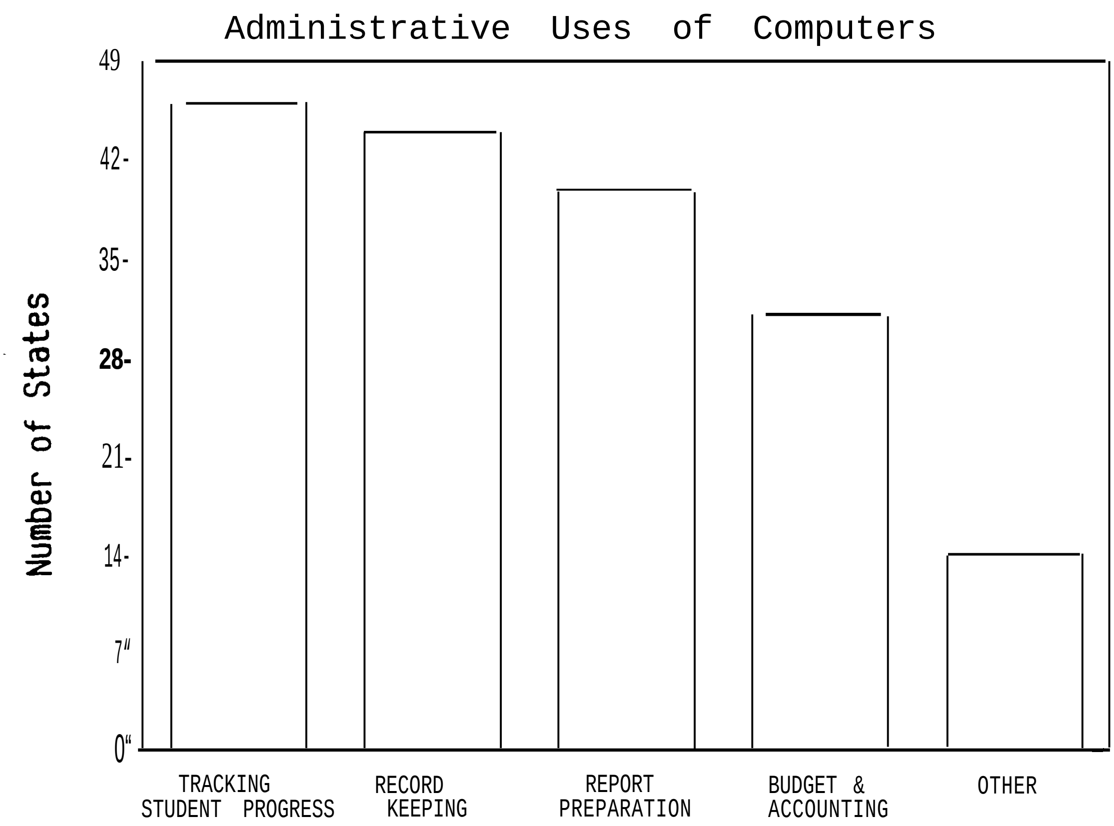
In the future, sophisticated diagnostic/prescriptive software packages might be developed, further blurring the distinction between administrative and instructional uses.

Administrative Uses Of Computers

The most frequently cited administrative uses of the computer were tracking student progress and record keeping. (See figure 2-5) When State coordinators listed other administrative uses, they often mentioned that computers are used for report preparation, for budgeting and accounting, and for evaluation purposes to select eligible

* The respondents also wanted to demonstrate that they were not using the Chapter 1 funds they receive to administer the program to purchase computers. (The State's administrative allocation is the greater of two amounts — 1 percent of the State's total allocation or $225,000.) According to one coordinator, 'computers can be used for administrative purposes, but must be purchased and used primarily for educational purposes."

FIGURE 2-5



SOURCE: OTA Survey of State Chapter 1 Coordinators” students and target schools. Computers are also used to compile and analyze data (especially student performance data and survey data), to prepare diagnoses and prescriptions for individual students, to assess program needs, to review software, and for word processing. These applications are very closely linked to the instructional component of Chapter 1.

Computers are also being used to compile, analyze, and report data to other Federal, State, and local agencies. While not many State Chapter 1 offices are using computers for these purposes, several State coordinators expressed great interest in the potential for technology to enhance coordination among programs at all levels. One State uses computers to compile performance data and report it to a Technical Assistance Center. Another uses them to determine mobility and service patterns for planning and reporting in the Migrant Education Program. This computerized system "transfers educational information when a child moves from one area to another." Finally, one State has a computerized evaluation system to report data from LEAs to the SEA. This system was installed in 1985 as a result of recommendations made by the State's task force on evaluation. According to the coordinator, the system was not difficult to implement. The coordinator believed that LEA, SEA, and Federal databases could be linked via computer to simplify reporting procedures.

Administrators and teachers can benefit from advanced administrative applications. In the future, computers might be used to enhance coordination between services provided under Chapter 1 and other special programs, e.g., Special Education programs and Bilingual Education programs. Currently, computers help enhance coordination between Chapter 1 programs and regular classroom activities. For example, in some school districts, regular classroom teachers receive a printout of work students have completed in their Chapter 1 class as soon as the Chapter 1 class period ends.

Instructional Uses of Computers

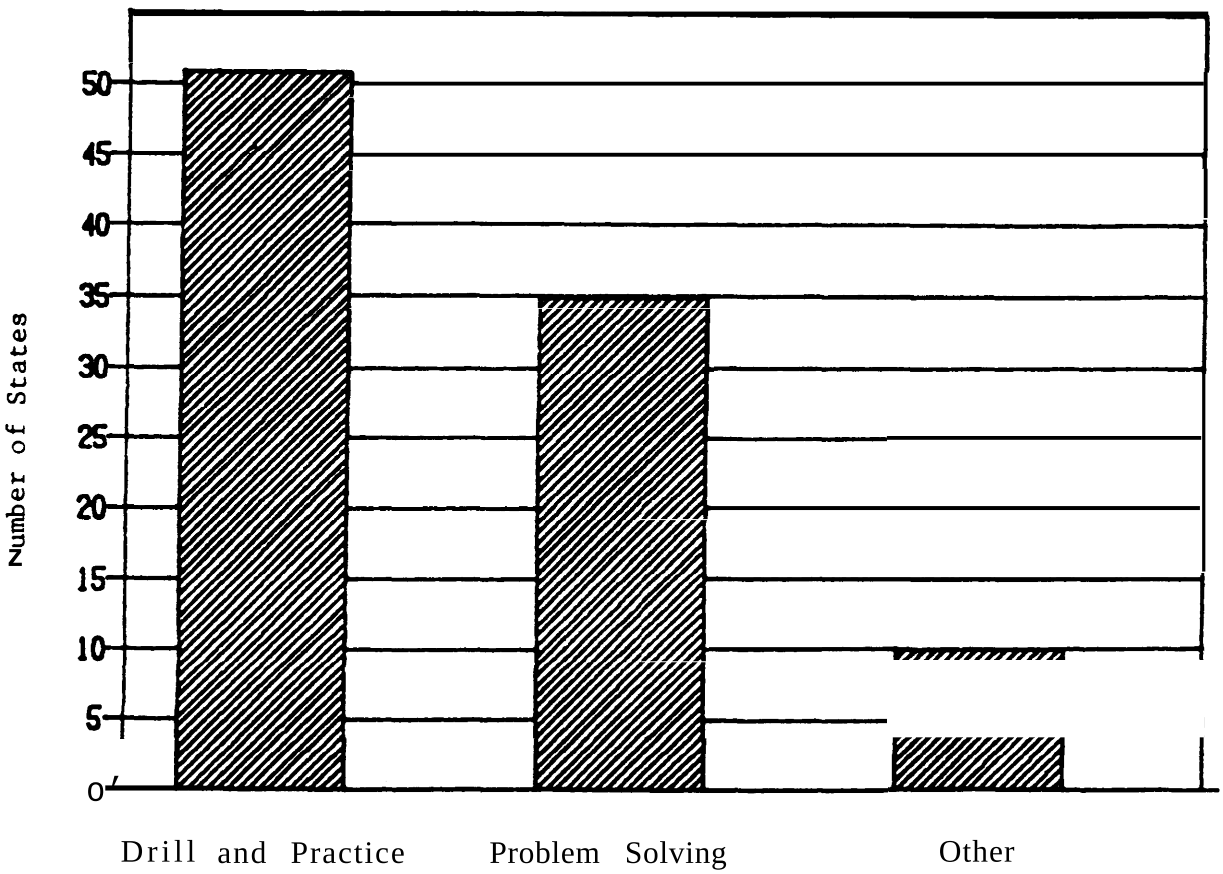
Every State coordinator reported that computers are used for instructional purposes in Chapter 1 programs. “ On the questionnaire, instructional uses were characterized as drill and practice and/or problem solving in reading and/or mathematics. In addition, the category of "other" was provided. Coordinators were asked to check all items that applied.

All States reported using computers for drill and practice in reading and mathematics. Thirty-five of the States also reported using computers for problem solving activities with their students. Ten States reported other instructional uses as well (See Figure 2-6); these uses include teaching writing skills and language arts, counseling students, and reporting to parents.

The finding that all States use computers for drill and practice for either mathematics or reading skills development is not surprising, since the first instructional software was principally designed for drill and practice. Much of the software available at this time still falls into that category. (See Figure 2-7) Only in the last few years has software aimed at developing students’ higher order thinking skills been introduced. It is interesting to note the large percentage of States (69 percent) which reported using computers for problem solving with Chapter 1 students. In the past several years, many schools have taught students to program in LOGO and other languages as a way of improving thinking skills. Recently, 33 Chapter 1 sites have implemented the Higher Order Thinking Skills (HOTS) program, a computer-based compensatory education program that focuses on developing students' problem solving skills. According to Dr. Stanley Pogrow, the designer of the HOTS program, ‘preliminary data indicate that the thinking skills approach can not only enhance thinking, but can also produce even greater substantial basic skills gains than traditional approaches for students in grades 4-6."[19]

Figure 2-6

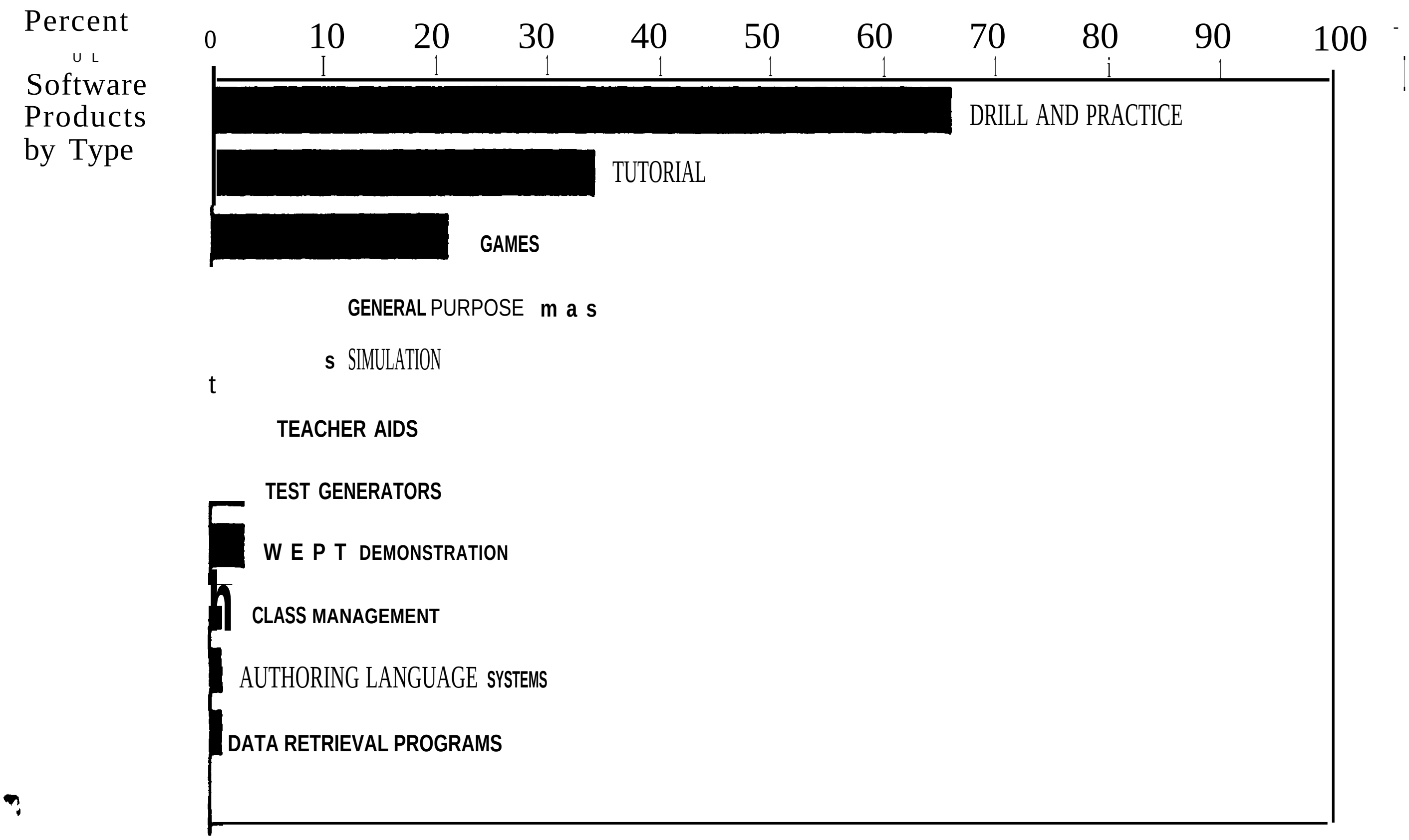
Chapter 1: Instructional Uses of Computers



Source: OTA Survey of State Chapter 1 Coordinators.

FIGURE 2-7

Software Availability



SOURCE: Based on data extracted from The Educational Software Selector (TESS) Database, May 1986, personal communication, Bob Haven, Educational Products Information Exchange (EPIE), Water Mill, NY.

The Chapter 1 coordinators expressed differing views about the appropriate instructional uses of computers with disadvantaged children. Some felt that, because the purpose of the Chapter 1 program is to provide supplemental educational services to these targeted students, and because these students are deficient in basic skills, it is appropriate for them to use computers for drill and practice in their Chapter 1 classes, especially if coordinators insisted that Chapter 1 students must also master problem solving skills as well. They contended that basic skills and higher order thinking skills are inexorably linked. Without teaching educationally disadvantaged students higher order skills along with basic skills, They will never perform at or above their grade level. These educators fear that the Chapter l students will remain disadvantaged because they will not be able to solve complex problems. If computers can help teach problem solving, these coordinators stated, then Chapter 1 students should have access to this use of the technology.

The Use of Computers by Limited English Proficient Students in Chapter 1*

In contrast to the use of computers for instruction among all chapter 1 students nationwide, only 13 coordinators reported using computers are used for instruction in States that have a large population of limited English proficient (LEP) Chapter 1 students. Fifteen States said they do not use computers with their LEP Chapter 1 students, and 13 coordinators said they did not know if computers are used in Chapter 1 programs that serve LEP students. In addition, 10 coordinators mentioned three reasons why the question was not applicable to their States: (1) because "no LEAs have large populations of LEP students;" (2) because the regulations for Chapter 1 do not require States to identify students on the basis of their proficiency in English ("LEP students are

19. Dr. Stanley Pogrow, University of Arizona, College of Education, personal communication, Mar. 3, 1987. Pogrow also reported that at one HOTS site, 10 percent of the Chapter 1 students were rediagnosed as "gifted" after 1 year in the program. At another site, 36 percent of the Chapter 1 students made the school% honor roll.

* For a more complete discussion of this topic, see Chapter 30fthis report.

not eligible for Chapter 1 based on LEP status only"); or (3) because the State does not distinguish between LEP Chapter l students and non-LEP Chapter l students.

In the 13 States where computers are used with LEP Chapter 1 students, the coordinators indicated that instruction in reading, writing, mathematics, and language arts is provided. They suggested that the LEP students need to develop their language skills and that drill and practice programs can help to reinforce those skills. One coordinator believed that computers are especially helpful to LEP students in class because "somecan read better than they can understand oral language."

Computers are used in a variety of instructional settings to teach LEP Chapter 1 students, including in classes for English as a second language. One coordinator said that many LEP students are being exposed to computers in State bilingual education programs if they are not using computers as part of their Chapter 1 instructional services. Two coordinators in western states said that computers were used in Chapter 1 programs which served a large proportion of Native American students.

The Use of Computers As a Remedy to the Aguilar v. Felton Decision

Less than half of the States (23) have used or are using Chapter 1 funds to purchase computers as a remedy to the Aguilar v. Felton decision,* while four additional States plan to do so in the future. Among these 27, five States use or plan to use district or statewide computer networks, two States plan to use mobile vans, and eight plan to use both vans and networks. In addition, six of these 27 States suggested other uses or planned uses in addition to the mobile vans and/or networks. These other methods

* Two of the remaining 28 States cannot provide services to nonpublic school students directly owing to provisions in their State constitutions. Third party organizations in those States receive a percentage of the SEAS allocation to provide services to eligible nonpublic school students. This arrangement is known as abypass.

include using technology in public school programs to which the private school students are bused, in CAI labs at neutral sites in programs which enable parochial school students to take computers home with them.**

In States which are using computer-based instructional systems to serve Chapter 1 students on the premises of nonpublic sectarian schools, coordinators are very concerned about equitability. In fact, it appears that many States are restricting or preventing the use of computer-based instruction because of that concern. Coordinators stated that ‘the computers are replacing teachers in the nonpublic schools."

As a result of the Supreme Court’s decision, neither public nor private school teachers are allowed to provide instruction during Chapter 1 classes on the premises of the nonpublic sectarian schools even when the children are using the computers to receive those services. In States using various configurations of computer systems to serve some nonpublic school children, nonpublic school staff supervise the students receiving Chapter 1 instruction. ‘Nonpublic school staff˜ refers to parents, volunteer aides, secretaries, or library aides. The staff are trained to use the computers and to monitor the classrooms. Many coordinators said that the computer programs themselves are often very limited: ‘computers can only remedy student% learning difficulties if they are made clear in the computer program.” Thus, according to one coordinator, "the CAI programs may provide very shallow instruction. But it is better than nothing according

---

** One coordinator was very enthusiastic about the benefits of such a ‘take-home” program which is being tested in his State. The following is his description of the program:

> Kids and parents go to a neutral site for one evening to learn about CAI and to learn how to hook up the computer to their television set. They have the computer for up to six weeks. Parents provide supervision. [Sometimes] the public school person will make home visits. More often, they are in contact with parents over the phone. [After six weeks,] the kids and parents return to the neutral site for more instruction. . . The program increases parental involvement, and it makes the instruction more meaningful and exciting.

Despite his enthusiasm, the coordinator said that he does not see the program spreading: ‘People are still fighting for alternatives."

to the nonpublic school administrators.” Other coordinators echoed that opinion:

> I don’t believe the technology will be as effective as teachers. But we’re faced with a choice: either we serve the kids with technology or we don’t serve them at all.

> Computers aren't really complete remedies. You need a good teacher in the classroom. The computer reinforces what the teacher has taught.

While some coordinators were not optimistic about the present state of instructional software, others believed that future developments of both hardware and software may be able to provide a greater degree of instruction and tutoring geared to students’ needs. Three States are trying to use technology as an alternative means of “bringing” teachers into the nonpublic sectarian school% Chapter 1 CAI lab. One State uses an audio telecommunications network which allows students to communicate with teachers while they are using the terminals. One State currently uses and another State is about to install "e-mail" — electronic mail. This enables students and teachers to communicate with each other via computer. To the coordinators in these and in other States which use CAI in Chapter 1 classes in nonpublic schools, finding ways to improve this method of delivery is very important because networked computers might become the remedy of choice in school districts that can afford to purchase them. According to one coordinator, ‘[nonpublic] school parents are resistant to having their children bused to neutral sites or to the public school; they are not resistant to CAI."

State Technical Assistance

States provide a variety of technical assistance, including teacher training, to LEAs regarding the use of computers in Chapter 1 programs. In 15 States, teachers and administrators receive technical assistance and training from an educational technology consultant who is hired by or works in the State’s Department of Education.[20] In another

---

20. According to the Electronic Learning 1986 Annual Surveyof the States, every State has an office of educational technology or an educational technology specialist or consultant in the State’s department of education. The degree of coordination between such offices or consultants varies and special programs like Chapter 1 varies from State

13 States, Chapter 1 offices within the SEA provide technical assistance and some teacher training on the use of computer-based technology at State and/or regional workshops.* There is some overlap between these groups: four additional States that offer statewide and/or regional workshops also work with a "State educational technology consultant. Three more States sponsoring such workshops also work with Chapter 1 technical assistance centers (TACS); in one State, teachers and administrators receive assistance in workshops and from vendors, and in another State assistance is provided by an educational technology consultant and/or by vendors. It is important to note that those states which provide technical assistance to teachers and administrators in workshops or in conjunction with a State educational technology consultant are least likely to rely on TACS, vendors, or LEAs to provide additional assistance. In several other States, teachers and administrators received technical assistance and some training from a combination of sources: from TACS, from vendors, or from LEAs.[21] Only two States relied upon just one of these sources for assistance. Only one coordinator indicated that the State had no formal means of providing assistance or training to Chapter 1 teachers or administrators regarding the use of computers.[22]

---

to State. The survey noted that 25 States make 'special efforts to provide computer access to Chapter 1, handicapped, or limited English proficient students." Jack L. Roberts, Editorial Director, Electronic Learning, personal communication, September 1986; and Fran Reinhold, 'Computing in America: Electronic Learning's Annual Survey of the States," Electronic Learning, vol. 6, No.2, 0ctober 1986,p. 28.

* In one of these States, some Chapter 1 teachers receive training via a closed circuit television network which broadcasts to 20 regional education centers.

21. Approximately 38 percent of all districts have full-time or part-time paid computer consultants; Reinhold, op. cit., p. 28.

22. A 1983 survey of State coordinators about the use of computer technology in Chapter 1 reported that coordinators said "the subject should be included in general technical assistance training programs." They gave some priority, but not the highest priority, to "this subject in relation to the overall technical assistance needs for administering Chapter 1 programs. In addition, they ranked the types of technical assistance most likely to be useful in the following order: (1) "an SEA-sponsored conference and/or regional technical assistance meetings;" (2) "consultant services;" (3) "a network for disseminating information on effective practices;" and (4) a conference sponsored by the State Department of Education. For more information see R.F. Cheuvront, "Information on the Use of Computers in Chapter 1," Colorado Departmentof Education, unpublished survey, January 1983. Also see Reisner, opt. cit., p. 20.

Two additional States provided assistance through computer consortiums. In one of these States, the consortium, which receives funding from the private sector as well as the State, works in conjunction with the State% regional educational service centers to provide assistance and training to all teachers and administrators including those who work in Chapter 1 programs. In the other State, a technology information program and a computer consortium center were established 3 years ago. The center% purpose is to train teachers and to develop software. The SEA does not run the center; it only facilitated its start. According to the coordinator, “the center is completely self-supporting." Districts pay a fee to belong to the consortium and to receive services.

While the two State consortia provide in depth training and assistance, the length and quality of assistance and training Chapter 1 teachers and administrators receive varies widely from State to State. In one State, teachers and administrators go to one of nine "high-tech" labs which have a variety of computers to receive training, software, and manuals. Some States hold Chapter 1 conferences for teachers and administrators annually or biannually and devote some time to computing at these conferences.* The focus on computing in the sessions may be on administrative/management applications (for district coordinators and/or for teachers), instructional applications, or both. Some State coordinators admitted that it is difficult for them to arrange workshops on instructional uses of computers. They rely on vendors, TACS, or LEAs because, “State-level people are compliance oriented, and people at the local-level are instructionally oriented." Some States hold workshops on management applications for administrators and encourage teachers to attend classes on computers at ‘Chapter 1 Summer Institutes"[N] or at in service activities during the school year. In many States, attendance at classes or workshop sessions on computing is optional. Despite the efforts States have made to

---

* In one State that sponsors an annual conference for special education teachers and Chapter 1 teachers, the coordinator said the amount of time allotted to discussing instructional and administrative use of computers has increased from a 1 hour session 3 years ago to 40 percent of the conference today.

provide training to Chapter 1 teachers, coordinators reported that the need for training is still great. According to one coordinator, "there is a need for massive, wholesale, consistent teacher training.”

In addition to providing training and technical assistance to Chapter 1 administrators and teachers, some State Chapter 1 offices oversee software evaluation, dissemination, and development efforts. In one State, a computer-managed instructional software package and its documentation, developed by a Chapter 1 teacher in the State, has been made available to all LEAs. This State and a few others provide LEAs with public domain software for their Chapter 1 programs. Some coordinators stated that it is still difficult to find software that meets the needs of Chapter 1 students. One coordinator says, “Our State% biggest stress is locating appropriate software."

State Policies for The Use of Computers in Chapter 1 Programs

More than twice as many States, (22), have policies regarding the use of computers in Chapter 1 in the 1986 OTA survey as did those in a previous study in 1983(10).[23] The “ following factors may have led to this increase: (1) the increase in the number of computers in schools in general; (2) a strong interest in managing technology on the part of State agencies; (3) a desire on the part of Chapter 1 administrators not to repeat mistakes made in the early days of Title 1 when "a lot of equipment was purchased but never uncrated;" and (4) the Aguilar v. Felton decision, which has heightened concern about program compliance.

State policies range from a one page list of questions for district coordinators that provide a framework for planning to documents of several pages in length which state explicitly how computers should be used. Many of these policies, regardless of length, require districts to show how they will plan for the introduction of the technology, how computers will help meet the program’s instructional objectives, and how teachers’ will

23. Cheuvront, op.cit.

be trained to use the computers. For example, one State requires a “written justification [for the use of the equipment] before the purchase is approved" Another coordinator said, "We do not endorse the purchase of CAI equipment without an instructional design and a plan to provide in service training to teachers. [Furthermore,] the number of students must justify the purchase." The rigorous nature of policies like these reflects many administrators’ commitment to assure that computers will be effectively used.

Many of the State policies contain regulations regarding the use of Chapter l funds to purchase and/or lease computer hardware or software. Several States have set a limit on the percentage of an LEAs budget which can be expended on computers. Other State coordinators think such limits are unnecessary: "if 50 percent of a project’s allocation goes toward the purchase of computers, that may be o.k. if they can justify the purchase via needs assessment." Seven State% policies regarding the use of Chapter 1 funds to purchase computers reflect section 555(c) of the Chapter l legislation, which states that Chapter l funds may only be used to benefit Chapter l students.[24]

Other policies apply general provisions in the Federal regulations to specific uses. For example, one State% policy reflects the "supplement, but not supplant" provision of the legislation: "neither the Chapter 1 computers nor the time spent by students in a Chapter 1 computer-assisted program may count toward meeting State requirements of computer literacy." A few States, which contend that the intent of the Chapter 1 legislation is to provide students with individualized instruction from a teacher, have policies specifically prohibiting computers from replacing teachers.

---

24. ‘A local education agency may use funds received under this chapter only for programs which are designed to meet the needs of educationally disadvantaged students. . . and which are included in an application for assistance by the State educational agency." Public Law 89-10, sec. 555(C).

Finally, one State policy applies strictly to administrative uses of computers. This State with a large population of migrant students mandates that all migrant regional offices must use the same file program to maintain student data and to report to the State.

Evidence of Instructional Effectiveness

Research on the effectiveness of computer-assisted instruction in general spans almost two decades. Coordinators were asked if they were aware of any research studying the effectiveness of technology in Chapter 1 programs in their States. Ten coordinators responded positively to the question. They indicated that the results of research in their States varied. In some projects, students did show marked improvement. In others, the gains they made were not significant. According to one coordinator, the results of research conducted in his State showed that "students did not [make] significant gains as a result of computer assisted instruction. Their attendance and attitudes improved." Another coordinator found that '[owing to] variations in programs and in the ways in which they use computers, it is difficult to strictly credit [gains] to computer-based instruction." Wide variations in evaluation design, program operation, and types of data collected also make it difficult for State coordinators and others to assess the role CAI plays in increasing educational gains for Chapter 1 students.

Evidence of Cost Effectiveness

Despite the amount of money States have invested in computer technology, only 10 coordinators were aware of evidence suggesting that the use of computers in Chapter 1 is cost effective. Six of these States had evidence to suggest that fewer instructional aides are needed and that more students are served when computers are used in the program, two States reported that computers allow students to progress at a faster rate, and the remaining two States had evidence only pointing to the need for fewer aides when computers are used.

These coordinators' comments on the issue of cost effectiveness were mixed. One coordinator is "actively discouraging purchasing computers for drill and practice [because] it is very expensive." That State'ss coordinator said, "You can buy a workbook for 25 cents. A computer costs $2,000." In contrast, another State coordinator agreed that computers were much more expensive for drill 'and practice than workbooks, but felt that the extra costs are justified because students' time on task is increased significantly. A third coordinator said that the use of technology should be more closely linked to cost effectiveness:

> I detect the absence of cost-effectiveness criteria. The first year [a district invests in computer technology] is almost free. The vendors want in the door. After that, LEAs can't get continual funding. Plus, the copyright laws require schools to buy several copies of software.

What Do Computers Enhance? What Do They Replace?

Little consensus exists among coordinators about what computers actually enhance. The one area of general agreement is that computers help teachers improve the ways they manage their classrooms. Many coordinators believe that computers free teachers from tedious tasks. According to one respondent, computers increase 'the speed of management." Another coordinator noted, 'computers do not replace teachers. They 'replace' teachers where they belong — providing direct instruction to students." Finally, one coordinator said, "there is a valid use of microcomputers in district management of Chapter 1 programs and all instructional programs."

Almost every coordinator believed that computers enhance motivation. According to several coordinators, many Chapter 1 students who use computers are more motivated to do their work because the computer is nonjudgmental, it allows students to work at their own pace, it provides instant feedback, and it makes "seatwork" more interesting.

Some coordinators also suggested that computers enhance students' self esteem: using such sophisticated machines enables educationally disadvantaged children to believe they are capable of reaching the same goals as their higher achieving peers.

At the same time, however, coordinators admitted that the motivational benefits of computer use are hard to measure empirically. Some coordinators wondered how long such benefits will last. Almost every coordinator agreed that it is difficult to assess the role computers play in increasing educational gains for Chapter 1 students.[25]

Coordinators had different opinions about how computers should be used to maximize achievement gains. Many said that computers should be used strictly for skills reinforcement. 'Computers enhance reinforcement. They give students more-time to practice at their own pace while teachers provide small group instruction to other students." Other coordinators feel that using the computer solely for reinforcement restricts the power and the capability of the technology. According to one coordinator, "drill and practice is an easy out."

According to almost all of the coordinators, whether or not the technology enhances instruction is dependent upon several factors. As two coordinators noted:

> In my experience, the advent of [computer based instruction] has been and can be beneficial to the program provided that it is carefully managed and monitored by LEAs and SEAS and that it relates to the educational program, that it is a supportive device to the program, and most important, that staff receive in service training six months to a year before the technology is put into the classrooms.

> You just cannot purchase computers and hope they clothe job for you. There must be district-level teacher training programs which show teachers how the technology can be used to enhance coordination between the Chapter 1 classroom and the regular classroom. There must also be [some way] of evaluating software.

---

25. Assessing the effectiveness of CAI is a very difficult problem. Researchers have employed a variety of methodologies in their attempts to measure gains in student achievement from computer based education. For more information on the methodologies and results of experimental studies see David Stern and Guy Cox, 'Assessing Cost-Effectiveness of Computer-Based Technology in Public Elementary and Secondary Schools," OTA contractor report, Jan. 8, 1987.

Almost every coordinator said that the degree to which computers enhance instruction is primarily dependent on the classroom teacher. The need for training and technological expertise is clear. One coordinator said, ‘... most school districts don’t have staff who have expertise with computers. Thus, they don’t utilize computers as they should." Another coordinator added, "If you have teachers who are not trained to use the technology, they won’t use it. That's a bad use of limited resources. In places where teachers have been trained, the technology complements the program."

Given the fact that coordinators believed "computers are an advancement, but not a replacement" and that teachers are the key to effective uses of computers, it is important to note that several coordinators still said that computers are replacing teachers in public schools as well ‘s private schools in their State. This situation, which appears to be the result of a lack of funds, creates a real dilemma for State and local officials. It is not clear how widespread the problem really is, but its existence was mentioned by several respondents. One coordinator said, ".. . computers are replacing teachers in a few LEAs," and another noted, "If you can’t pay for teachers, you pay for aides. If you can’t pay for aides, you pay for computers."

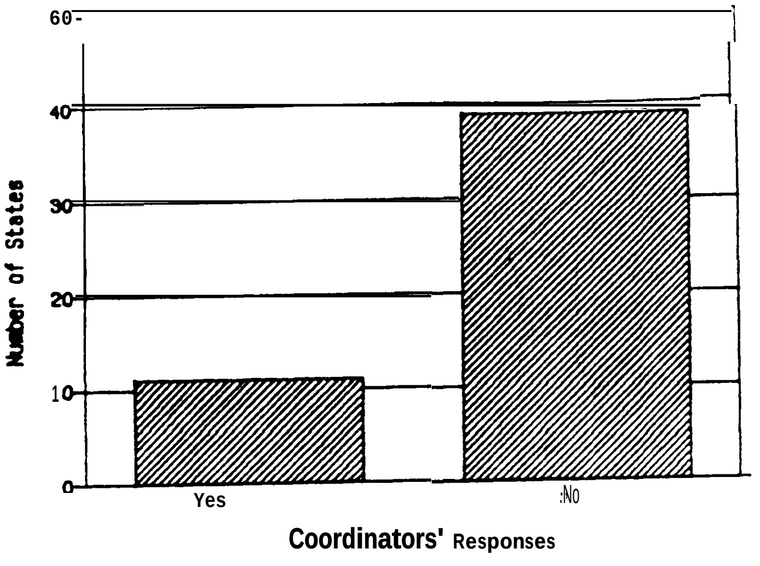
Coordinators also contend that computers are replacing more traditional forms of drill and practice provided by workbooks, seat work, and other audio-visual instructional materials.

Is Computer Technology A Priority? Will it be in the future?

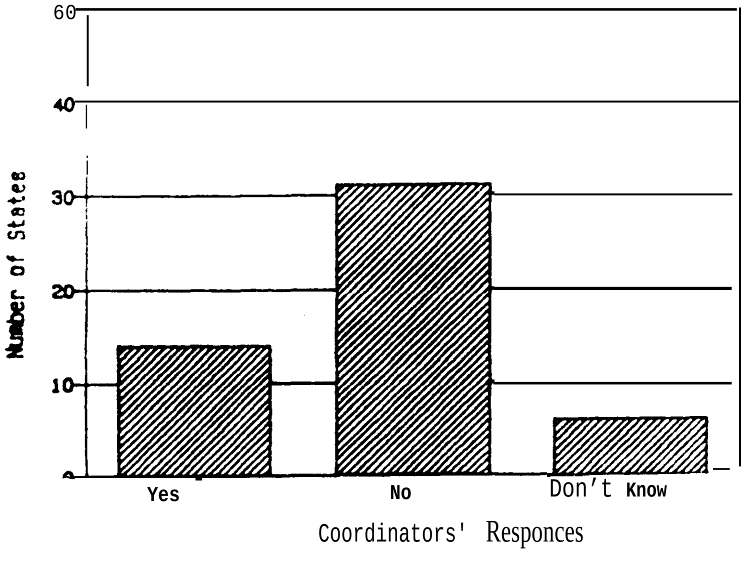
Although computers are being used in Chapter 1 programs to some extent in all States, only 11 coordinators indicated that investing in computer technology is a priority in their State. Thirty-nine coordinators said that it is not. (See Figure 2-8) Coordinators cited two factors that can influence the setting of priorities. First, if there is a high technology initiative in a State or if the State education agency or legislature has taken an active interest in educational technology (e.g., marinating computer literacy

FIGURE 2-8

IS INVESTING IN COMPUTER TECHNOLOGY A PRIORITY NOW?*



WILL IT BE IN THE FUTURE**



* **Note:** One State coordinator did not answer the question.

** In 4 States where investing in computer technology is not a priority now, it will be in the future.

In 6 States where investing in computer technology is not currently a priority, coordinators do not know if it will be in the future.

In one State where investing in technology is now a priority, the coordinator said it will not be in the future.

In another State where investing in computer technology is currently a priority, the coordinator does not know if It will be in the future.

SOURCE: OTA survey of State Chapter 1 coordinators.

courses) then the Chapter 1 program in that State is more likely to view investing in technology as a priority. The second factor that influences priorities for Chapter 1 services is, quite simply, money. Some coordinators said that they would invest in technology if they had more money: ‘If there was enough money so that I could be sure I wasn’t taking anything away from kids, then I’d be more willing to approve purchases." In many States, especially States with small, rural districts that receive very small allocations, there is not enough money to purchase computers after teachers’ salaries are paid.

One way of dealing with limited resources is to use technology more and reduce the number of teachers and aides. However, most coordinators are committed to maintaining or increasing the human resources, as noted above. Whether or not investing in technology is a priority, all of the coordinators said that they do not believe computers should ever replace teachers. Their common belief was best expressed by two coordinators:

> Chapter 1 kids need encouragement more than any other type of student. They need encouragement more than skills. They'll learn the skills once they are motivated. We need computers as a support to help motivate kids, but we need teachers more. With all of their lights and buzzers, the computers cannot give hugs and smiles. The computer cannot say to a child, "Hey, I'm proud of you. You did well." or "I am glad to see you today~’

> The great advantage of personnel is they can interact with kids. Computers can do that to an extent, but they are not sensitive enough to give kids warm, supportive feelings. We don’t assess that in Chapter 1. But one of the things we do best is help kids feel good about themselves.

Do Federal Regulations Affect the Use of Chapter 1 Funds to Purchase Computers?

Federal regulations require that equipment and materials purchased with Chapter 1 funds be used solely to benefit Chapter 1 students. When asked, on the mail survey, if they felt Federal regulations affect the use of Chapter 1 funds to purchase computers, an overwhelming majority (46) State coordinators said no. However, three coordinators said that Federal regulations discouraged computer purchases in Chapter 1.* They indicated

* One coordinator did not answer the question.

that a valuable resource was being wasted because some computers purchased with Chapter l funds sat idle when they were not being used by Chapter l students.26

Its important to note that Chapter 1 funds can be combined with other funds to purchase computer hardware and software as long as the costs and the access to the technology are prorated fairly between Chapter 1 and non-Chapter 1 students. The follow-up telephone survey revealed, however, that some coordinators did not understand how the use of computers can be prorated and that others did not allow such use to be prorated. Coordinators expressed great concern about compliance. Although coordinators were reluctant to suggested any specific changes in the regulations, four coordinators said that the Federal Government needs to clarify or to provide additional guidelines in this area. One coordinator suggested:

> there be some clarification about the use of Chapter 1 funds to purchase computers. [We need to know:] can the equipment be used in the afternoon, for example, for non-Chapter 1 students if Chapter 1 students use it in the morning? Who will pay for the repairs [if costs are prorated]? Cost-sharing guidelines would be helpful.

Coordinators' Suggestions

There was little agreement among coordinators about what action, if any, Congress should take regarding the use of educational technology in Chapter 1 programs. Several agreed with the coordinator who said, "It should be left up to the States and the LEAs to determine what type of materials and supplies it takes to operate a successful program in the schools." Another coordinator added, "Leave it up to LEAs to decide whether or not and how to purchase computers. Give us the flexibility to determine what our needs are and how best to meet them."

26. According to a 1983 report, the regulation which prohibits use of Chapter 1 funds for non-Chapter 1 purposes may effect the "availability" of computers in Chapter 1 programs. This report also cited anecdotal evidence which indicated that "some local [school] systems have nevertheless decided not to use Chapter 1 funds for computers because of their concern for maintaining compliance with [Federal regulations]." For more information see Reisner, op. cit., p. 9.

Several other coordinators stated, however, that funds should be set aside for the purchase of educational technology. Many coordinators in rural States said that funds should be set aside for districts with small Chapter 1 allocations. "Small school districts' allocation is often less than $20,000. You aren't going to be able to do much with technology because you have to pay a teacher% salary, which comes to $16,000 with fringe benefits."

Whether or not funds are set aside for the purchase of computer based technology in Chapter 1, many coordinators believed that Federal regulations regarding the use of Chapter 1 funds to purchase and/or lease hardware and software should be amended or clarified. Several coordinators wanted regulations or legislation to clearly state that "it [is] legal to purchase computers and to "allow the purchasing to continue." Apparent confusion over the content as well as the intent of the regulation prohibiting the use of Chapter 1 funds for non-Chapter 1 purposes has resulted in differences in the ways computers are purchased and used among States. In some States, coordinators have made policies based upon a strict interpretation of this aspect of the Chapter 1 legislation; these States do not allow the costs of computer use to be prorated. Other States have dealt with this uncertainty by encouraging the use of Chapter 2* funds or local or State monies to buy hardware, using their Chapter 1 funds to buy software only.

Some coordinators felt that the technology could be a big help in program evaluation. It has already enabled teachers and administrators to reduce some of the burden of administering the Chapter 1 program. These coordinators expressed hope that Congress will not discourage the use of computer technology for this purpose.

They also suggested that Chapter l databases could be created in the future so that LEAs, SEAS, and the Federal Government could share access to them. Some coordinators recommended that the reporting formats for National, State, and local evaluations be

---

* Chapter 2 of the Education Consolidation Improvement Act consolidated variety of categorical grant programs for education into a single educational block grant.

standardized. One coordinator pointed out that such a database and standard report format already exists in one portion of Chapter l programs. The Migrant Student Record Transfer System (MSRTS) transmits educational data from one LEA to another about students who move frequently owing to the agricultural season.* It has been operating for several years. This coordinator suggested that such a database could be installed for all Chapter 1 students, especially if individualized educational plans become mandatory. The coordinator added that such a database could also be used to track such students after they leave the Chapter 1 program.

If there was any agreement on future needs, it was with regard to the need for teacher training, for further research and development (R&D), and for "high-tech" demonstration sites. Many coordinators said that Congress needs to pay more attention to teacher training in the use of technology in Chapter 1 programs. According to one coordinator, ‘Congress needs to fund training programs and demonstration sites which are tied into these programs." Another coordinator said, ‘Congress should make provisions for training administrators at the State and local level as well as teachers and aides in the use of technology."

Coordinators also felt that Congress should invest money in R&D and in demonstration sites that incorporate state-of-the-art technology with various Chapter 1 curricula:

> We need to find out what kinds of technology work with Chapter 1 kids. We need demonstration sites that implement a variety of uses. Variety is important because different school districts have different needs.

Coordinators also seemed concerned that schools were not tapping the potential of new information technologies. One coordinator lamented the fact that very few software programs are presently available which make use of breakthroughs in artificial

---

* The (MSRTS) database located in Little Rock, Arkansas, contains the name and grade of all students who have been identified within the past 5 years. Each student’s record contains a variety of information, including courses of study, achievement scores, health information, LEP status, and special education status.

intelligence. Another said that schools have not realized the power of satellite communication. This coordinator suggested that this means of communication could provide a new range of opportunities for educationally disadvantaged children. For example, satellite communications could enable students to talk with leaders in politics, entertainment, and sports. A third coordinator commented:

> ...technology is ever changing. People are always finding new ways to use the technology creatively. Perhaps Congress should give money to TAC centers or to college and university labs to help develop new technologies or adapt existing ones to meet the needs of disadvantaged students.

According to the coordinators, the demonstration sites and R&D efforts should yield data on the effectiveness of computer based instruction for educationally disadvantaged children. Many coordinators lacked information on effectiveness or were skeptical of the existing data. "I'd like to see some empirical information that the use of computers is better than what we were doing before computers — some good, hard data." Another coordinator said:

> Technology is important. Maybe Congress should try things out in test sites, in a practical sense so that it (the technology) really meshes. Find out what works and what doesn't <u>in schools</u>.

IMPLICATIONS FOR FEDERAL POLICY

The findings of the OTA survey have several implications for Federal policy. In reauthorizing Chapter 1 of the Education Consolidation Improvement Act, Congress may want to consider the following:

- Clarify existing regulations regarding the use of Chapter 1 funds so that LEAs and SEAS know how to prorate the purchase and maintenance costs of hardware and software.

- Monitor the use of computers as a remedy to the Aguilar v. Felton decision. Many approaches are being tried; it may be too soon to make changes in legislation and/or regulations.

- Establish demonstration projects which integrate state-of-the-art technology into a variety of Chapter 1 programs. These projects could be implemented in a variety of ways, including matching funds, grants, monies that are set aside, or the Secretary of Education's discretionary fund.

- Encourage future R&D projects in the fields of cognitive and computer science to consider the needs of disadvantaged students.

- Encourage technology transfer efforts to be responsive to the needs of these students.

- Encourage dissemination of information about the use of educational technology in Chapter 1.

- Study the feasibility of a database for Chapter 1 students similar to the Migrant Student Record Transfer System. Such a database might be especially useful in districts where a high percentage of students move from school to school during the year, or where individual education plans (IEPs) are in use.

CHAPTER 3

THE USE OF TECHNOLOGY FOR STUDENTS WITH LIMITED ENGLISH PROFICIENCY

CHAPTER 3

THE USE OF TECHNOLOGY FOR STUDENTS WITH LIMITED ENGLISH PROFICIENCY

INTRODUCTION: STATUS OF LIMITED ENGLISH PROFICIENT STUDENTS

The fastest growing segment of school-age population in the United States today is the group composed of students with limited English proficiency (LEP).* During the period 1978 to 1982, while the overall population of students ages 5-14 declined by 6.2 percent, the limited English proficient population grew by 10.3 percent.[1] current estimates of the total number of LEP students range from 1.2 million to 6.6 million.[2] Whatever count one uses, this group of students is making a major impact on the educational system.

---

* The Bilingual Education Act defines "limited English proficiency" and 'limited English proficient" as:

> (A) individuals who were not born in the United States or whose native language is a language other than English;
>
> (B) individuals who come from environments where a language other than English is dominant, as further defined by the Secretary by regulation; and
>
> (C) individuals who are American Indian and Alaskan Natives and who come from environments where a language other than English has had a significant impact on their level of English language proficiency, subject to such regulations as the Secretary determines to be necessary; and who, by reason thereof, have sufficient difficulty speaking, reading, writing, or understanding the English language to deny such individuals an opportunity to learn successfully in classrooms where the language of instruction is English or to participate fully in our society.

1. Carol Pendas Whitten, Director, Office of Bilingual Education and Minority Languages Affairs, U.S. Department of Education, testimony before the U.S. Congress, House Committee on Appropriations, Subcommittee on the Departments of Labor, Health and Human Services, Education, and Related Agencies, Apr. 9, 1986.

2. The U.S. Department of Education uses a figure of 1.2-1.7 million school-aged limited English proficient children in 'The Condition of Bilingual Education in the Nation, 1986" based on an analysis of the number of children scoring below the 20th percentile (of their native-English age peers) on a test of Engish proficiency – the Language Measurement and Assessment Inventory (LM & AI), taken in the fall of 1982. This data was then factored to reflect growth from 1982 to 1986). U.S. Department of Education, "The Condition of Bilingual Education in the Nation" unpublished typescript, 1986.

The majority of these LEP students were born in the mainland United States, but growing numbers are immigrants or refugees. Up to a million persons, including undocumented entrants and refugees, are entering the country each year, predominantly from Asia, Mexico, and Central and South America.[3] Although LEP students can be found in every State in the Nation, they are most heavily concentrated (particularly Hispanics) in the border States and those States that are traditional areas of entry to the United States. California, Texas, Florida, New Jersey, New York, and Illinois have particularly large LEP student populations. Spanish is the predominant home language of LEP students in the United States, followed by the various Southeast Asian languages, but there are dozens of other languages which smaller numbers of LEP students speak when they first enter our schools.[4]

The immigrant children found on the doorstep of America's schools today present a special challenge to the educational system. Many have the multiple handicaps of poverty, the inability to speak English, and little or interrupted schooling, due to civil strife, famine, or poor economic conditions in their homelands. Many are illiterate in their native language. Educationally deprived, they are found to be retained in grade more often, drop out at higher rates, and achieve at lower levels than other students. Overall, students from homes in which a language other than English was predominate scored at least twenty points lower in reading than their classmates on the 1983-84 National Assessment of Educational Progress; Hispanics scored thirty-three points below their English speaking peers on the assessment.[5]

---

3. Business Council for Effective Literacy Newsletter, "Literacy in a New Language," vol. 1, No. 10, January 1987.
4. Bilingual Education Grant applications for FY86 included projects serving students speaking over 100 different languages. Ronald Saunders, National Clearinghouse for Bilingual Education, Wheaton, MD, personal communication, Feb. 9, 1987.
5. Phi Delta Kappan, "Newsnotes" vol. 67, No. 7, March 1986, pp. 543-545.

One of the most serious consequences of the LEP students' difficulties with education is reflected in their high dropout rates. While national figures reveal that three out of four American students graduate from high school, for some minority groups which include large numbers of LEP students the percentage of students dropping out before graduation is much higher. Native Americans have the highest dropout rate of any racial/ethnic group: 48 percent, with Hispanic students following close behind at 45 percent. These figures are even higher in urban areas, with some studies conducted in urban high schools showing dropout rates as high as 85 percent for Native Americans and between 70 and 80 percent for Puerto Ricans.[6]

What is the price society bears when a student drops out of school? According to research conducted by Henry Levin at Stanford University, the cost of high school dropouts, ages 25-34, conservatively, amounts to $77 billion every year: $71 billion in lost tax revenues; and $3 billion for welfare and unemployment; $3 billion for crime prevention.[7]

In order to address these serious educational problems, States, localities, and the Federal Government have all made substantial investments in helping LEP students attain the English language skills which are prerequisites to their being able to succeed in school and in society. The size of this effort varies considerably from State to State and from locality to locality, depending upon the numbers of LEP students identified in each.[8]

---

6. A study recently conducted by the Hispanic Policy Development Project has documented that in New York City the dropout rate for Hispanics is about 80 percent. Chicago and Los Angeles, respectively, have 70 and 50 percent Hispanic dropout rates. Institute for Educational Leadership, Inc., School Dropouts: Everybody's Problem (Washington, DC: Institute for Educational Leadership, 1986).p.8.
7. Ibid., p.2.
8. Due to different methods of defining the limited English proficient population, and State differences in funding local school districts, there are no overall figures showing State by State spending to serve these students. Some States, like California, which has

In 1985, the Federal Government provided approximately $685 million to serve the needs of limited English proficient students, but this figure includes all funding sources which impact this group, including Chapter 1, adult education, refugee education programs of HHS, and Bureau of Indian Affairs activities. Funding for the Bilingual Education Act itself totaled $139 million.[9] (See Table 1)

The Bilingual Education Act, Title VII of the amended Elementary and Secondary Education Act of 1965, is conceived as a capacity building program, one which provides seed money to local districts in the form of grants. (This is in contrast to the formula funding programs based on student count found in Chapter 1 and Chapter 2 of the Act.) The two largest Bilingual Education Act programs are the Basic Projects and Demonstration Projects — both of which award grants to eligible applicants to support the development and implementation of bilingual education projects at preschool and K-12 levels. The Department of Education estimates that three States — California, Texas, and New York — received approximately 50 percent of these grants in the 1985-86 academic year.[10] Instructional program grants make up the largest piece of the Bilingual Education Act, with FY85 awards totaling $94.7 million and serving 205,494 students.[11] In 1982, the most recent year for which data are available, the Education

---

identified 567,000 LEP students, have categorical funding to serve this group. This year the State of California will spend approximately $110 million for specialized services to LEP students. Norm Gold, Director of Bilingual Education, State of California, personal communication, Feb. 8, 1987. In other States, due to the nature of their localized school financing patterns, this information is not assembled in such a way as to break out spending figures for LEP students. Ron Saunders, National Clearinghouse for Bilingual Education, Wheaton, MD, personal communication, Feb. 8, 1987.

9. Carol Pendas Whitten, op.cit.

10. Irwin, et al., "Impact of Legislative Changes on Major Programs Administered by the Department of Education, Fiscal Years, 1980-1987," CRS 86-990 EPW (Washington, DC: Congressional Research Service, Nov.20, 1986).

11. Other programs supported under the Bilingual Education Act are those providing training to education personnel working with LEP students (Part C: $23,566,000) and support services for LEP activities (Multifunctional Resource Centers: $10,000,000 Evaluation Assistance Centers $500,000, Instructional Materials: $250,000, State Educational Agency grants for data collection: $5,0000,000, National Clearinghouse for Bilingual Education: $1,200,000, Research Program: $3,600,000). "Condition of Bilingual Education," op. cit.

TABLE 1

Federal Funding for Limited English Proficient Students, Fiscal Year 1985

	Millions of Dollars
Department of Education:	
Bilingual Education Act	139
Chapter 1 - Grants to LEAs	384
Chapter 1 - Migrant Education	68
Adult Education	27
Bilingual Vocational Training	4
Title IV, Civil Rights Act	7
Immigrant Education	30
Subtotal, Department of Education:	659
Department of Interior: Bureau of Indian Affairs	4
Department of Health and Human Services:	
Refugee Education*	17
Entrant program*	5
Subtotal, Health and Human Services	22
Total	685

SOURCE: Carol Pendas Whitten, Director, Office of Bilingual and Minority Language Affairs, U.S. Department of Education, testimony before the U.S. Congress, Subcommittee on the Departments of Labor Health and Human Services, Education and Related Agencies, of the House Committee on Appropriations, Apr. 9, 1986

* Note: These programs have since been transferred to the Department of Education.

Commission of the States estimated that Title VII funds accounted for about 60 percent of combined Federal-State expenditures for educating LEP students.[12]

Despite the increase in numbers of LEP students nationwide, Title VII local instructional programs served 27,380 fewer students in the 1985/1986 academic year than were served in 1980/1981, a decrease of almost 12 percent. Fellowships for graduate study in bilingual education teacher training decreased from 560 to 514 over the same time period, and the number of students in degree-oriented programs (including preservice, inservice teacher and administrator training) decreased from 11,000 to 5,590 over the same period. With funding for the Bilingual Education Act decreased by 14.3 percent from 1980 to 1987 (a decrease of 44.7 percent when adjusted for inflation), States and localities have had to bear **a** higher proportionate funding share in order to serve their increasing numbers of LEP students. The U.S. Supreme Court decision in Lau v. Nichols requires that all limited English proficient students receive instruction designed to meet their special needs. Unfortunately, in many cases local demand for instructional programs serving LEP students is negatively correlated with income, wealth, or other measures of taxing and spending capabilities; often those pockets with the highest concentrations of students in need of programs are least able to afford them. The percent of eligible students served by the Federal Title VII program varies according to the way the LEP population is defined. If one uses the low end of the U.S. Department of Education’s count, 1.2 million LEP students, then Federal programs reach approximately 20 percent of the eligible students; if one takes the figure of 3.6 million students, the high end of the Department’s estimate, only 8 percent are served;[13] and if one uses the 6 million LEP student count found in other studies, then fewer than 4 percent of the target population is

12. Irwin, et al., op. cit., p. 25.
13. Irwin, et al., op. cit., pp. 23-27.

served by the Federal bilingual program.

TECHNOLOGY AND THE LIMITED ENGLISH PROFICIENT STUDENT

Is technology being used as a resource for meeting the instructional needs of LEP students and, if so, where and why? Do limited English proficient students have as much access to classroom microcomputers as do their English speaking peers? What kinds of technologies are being used in teaching LEP students, and what are the implications of technological breakthroughs for future activities? What are the roadblocks to greater implementation of innovative technologies? The following sections deal with these questions.

Access

The question of access to technology for the student with limited English proficiency is a multifaceted one. Researchers note the "double barrier" faced by these students:[14]

> Language minority students who are limited in English proficiency have fewer opportunities to use and interact with computers than do the general population of students. They often experience a double barrier, the first resulting from their being in low SES, primarily minority schools, and the second resulting from their lack of English proficiency. In addition, the opportunities that they do have to interact with and use computers are often qualitatively inferior to those of the other students.

This lower rate of access to computers is confirmed by data from the 1986 National Survey of ECIA Chapter 1 schools.[15] This study was designed to obtain information regarding teaching practices of approximately 3,500 teachers from 1,200 schools nationwide who had at least one student in their class who received Chapter 1 or some

14. Donna M. Johnson, "Using Computers to Promote the Development of English as a Second Language," A Report for the Carnegie Corporation, unpublished typescript, November, 1985.
15. 1986 data from the National Survey of ECIA Chapter 1 Schools, conducted by Westat Corporation for the U.S. Department of Education.

other special service such as State Compensatory Education. The teachers were asked, among other questions, what subjects they teach and whether they use a computer to help teach the students in their classes. The results (Figure 1) show that the percentage of teachers who use computers in instructing their LEP students is consistently less than one-half the percentage of teachers who use computers in teaching other students. This holds true for both Chapter 1 teachers and regular classroom teachers. As one educator noted, where computers exist in a school, the line to use them is still along one, and the LEP student is put at the back of the line. His teachers see that the materials are almost always written in English, and assume that the non-English speaking student will not be able to profit from them.[16]

If one avenue of access to computer instruction is through Chapter 1 services, it could be assumed that the limited English proficient student who is in the elementary school is more likely to have access to computers than is his junior high or high school counterpart, approximately three quarters of all students receiving Chapter 1 services attend elementary schools.

Another possible barrier to computer access in the upper grades are the course-entry requirements. A 1985 survey of 20 high schools in California with high levels of Hispanic enrollment documents barriers to computer use by the Hispanic students. In these schools, like many others nationwide, the high school computers generally fall under the control of the mathematics and science teachers, and often there is a requirement that algebra be taken prior to entry to a computer course. The Hispanic students, who were less likely to participate in these courses, were consequently found to be less likely to enroll in the computer courses.[17]

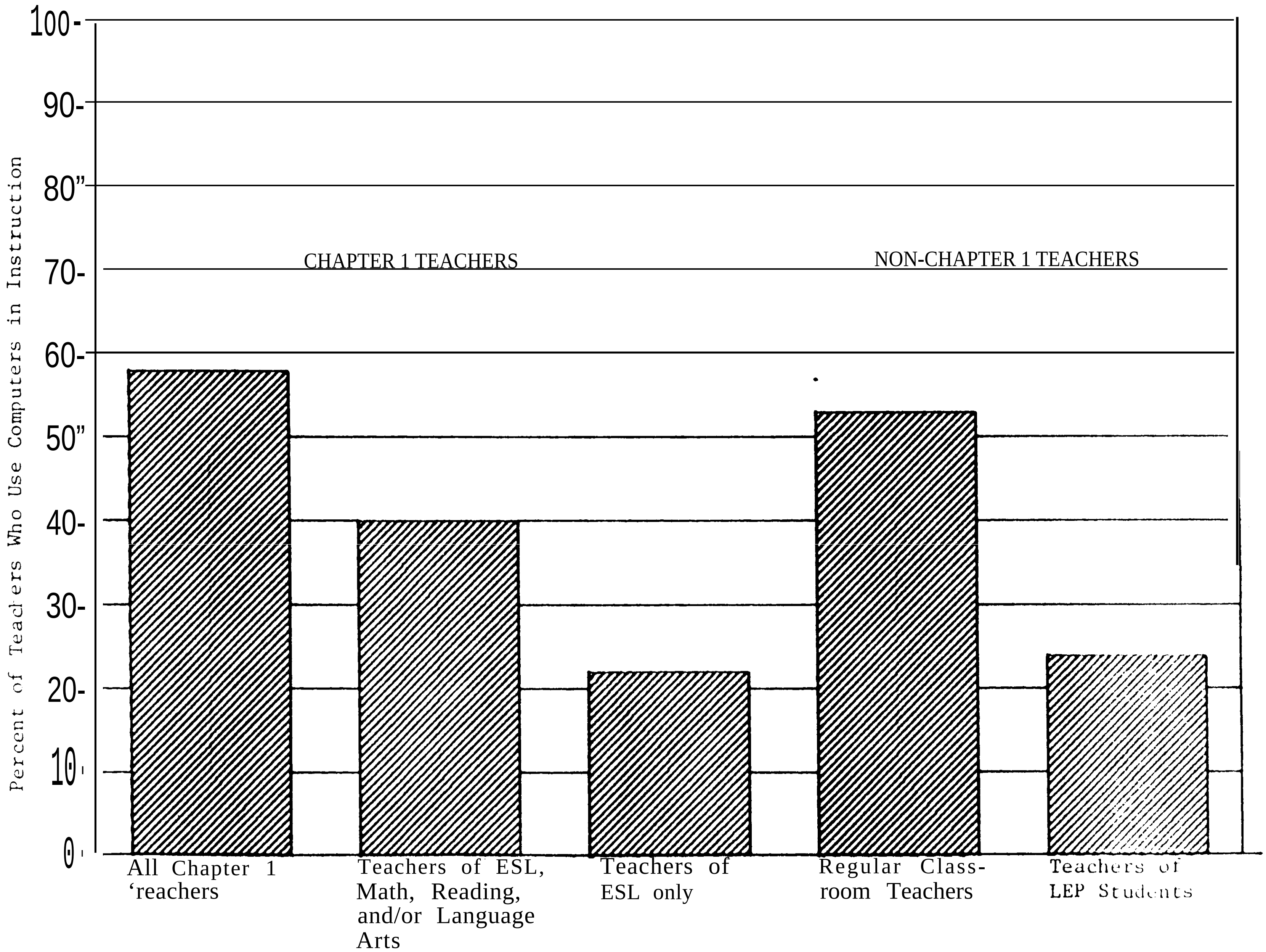
---

16. Esteban Diaz, Center for the Studyof Human Cognition, University of California at San Diego, videotaped interview, February 1987.

17. Arias, Beatrice ‘Computer Access for Hispanic Secondary Students: Barriers to Equity," paper presented to American Educational Research Association annual meeting, Chicago, IL, April 1986. Another study (Microcomputer and VCR Usage in Schools, 1985-1986, Quality Education Data, Denver, CO, 1986, p. 33), comparing Hispanic enrollment and microcomputer density in schools, showed no clear pattern of available computers

FIGURE 3-1

Teacjers* USING COMPUTERS IN INSTRUCTION



*In schools receiving Chapter 1, State, or other compensatory education, or special education scrvices.

SOURCE: Westat Corp., National Survey of ECIA chapter 1 Schools, 1986

Another factor found in Arias' survey, and also noted in analyses of Chapter 1 schools, is the limited access which poor students, including LEP students, have to computers outside of class time. This works in two ways, both to the detriment of these students. Their families cannot afford a home computer, and at school they often face the "locked lab" syndrome. In these poorer neighborhoods, school concerns about the physical security of the computers may result in policies limiting the access both students and teachers have to the machines. Computer rooms are likely to be available only during class as there are fewer staff available to monitor before or after-school computer activities. Schools in poor neighborhoods are not as likely to allow students to check a computer out for the weekend to "hack around on,"[18] and as a result, the student or classroom teacher in this setting typically does not have these opportunities to feel comfortable with a computer that use at home or outside the domain of the class period allows.

The other side of the question of equal access is the qualitative one: is there a difference in the kind of computer activities" in which the limited English proficient student is involved? Survey data[19] about computer use in low Socioeconomic status, predominantly minority, schools point to using the computer in a compensatory manner to raise achievement levels through drill and practice for low achievers. Data on Chapter 1 computer use also point in this direction, and both these uses correspond to what seems to be the predominant practice with LEP students. Some educators fear that computer-assisted instruction (CAI) used for remedial instruction alone may diminish a student% self-image; these educators emphasize that the low achieving student should

---

per student in schools with high percentages of Hispanic students.

18. Educator Sherry Turkle talks about the importance of 'making the computer your own", which comes from having the chance to play around on it, to try things on it in the less demanding atmosphere of nonclass time or in one's own home. Sherry Turkle, The Second Self: Computers and the Human Spirit (New York: Simon and Shuster, 1984).

19. This data shows that poor schools are gaining in their computer acquisition rate, but the numbers of computers per student is still lower than in wealthier schools. Henry Becker, Center for Social Organization of Schools, The Johns Hopkins University, "1985 National Survey of Instructional Uses of School Computers," 1986.

BOX A

TERMS: Bilingual Instruction Alternative Approaches

Bilingual education — a program in which students receive a substantial part of their initial instruction, including reading, in their native language. At the same time, they start studying English, usually during daily periods of intensive instruction in English as a second language (ESL). When the curriculum also includes the study of the history and culture associated with the home language, these programs ma-y also be referred to as bicultural or bilingual maintenance programs.

Transitional bilingual education — similar to bilingual education program with emphasis on phasing out of home language usage in all subjects as English instruction is gradually phased in.

English as a second language — a variety of approaches to teaching English to students who speak another language. (The term ESOL refers to "English for speakers of other languages") ESL commonly involves intensive instruction in English, often through the use of audio-visual materials, with emphasis on communication skills.

Immersion — a program in which teachers speak only English to their limited English proficient students. If the teacher in an immersion program understands the language of the students, cues them in their home language for clarification, and allows the students to respond when necessary in the home language, this is referred to as structured immersion.

Sheltered English or Sheltered Content — a technique for teaching academically demanding courses such as science and social studies in English to students not fluent in English. Typically teachers make subject matter more comprehensible by slowing down their speech, repeating key vocabulary words, and using visual aids, "hands-on" approaches, and similar nonverbal activities.

In practice, there is generally a good deal of overlap between these instructional approaches, blurring their distinctions.

---

1. Rick Holland, U.S. Congressional Research Service, "Bilingual Education: Recent Evaluations of Local School District Programs and Related Research on Second-Language Learning," Mar. 18, 1986, pp. 7-9; and 'Teaching Immigrant Children: Terms and Issues" Los Angeles Times, Jan. 13, 1987, p 29.

have the opportunity to learn more advanced computing applications such as word processing, database management, and programming, like his higher-achieving classmates.[20] Nevertheless, the achievement gains in basic skills which CAI has shown to provide have convinced many educators that remedial instruction is inappropriate use of the technology.

Why is Technology used in Bilingual/ESL Instruction

Schools are using technology to meet the needs of their students with limited English proficiency for two basic reasons —because it works, and because it provides a means to provide instruction where other resources are not available.

The burden for the limited English proficient student is not just learning the English language — he or she is also struggling to master mathematics, science, social studies, and other subject matter content, as well as learning study habits and the social skills needed to interact comfortably with his English speaking peers in the school setting. Whether the school uses a bilingual, transitional bilingual, English as a second language, immersion, or a mixed instructional approach, (see Box A) computer assisted instruction has been seen as one tool to boost the limited English proficient student in his climb over what may seem overwhelming academic and social hurdles.

Researchers have looked at studies of computer-assisted instruction and computer-assisted language learning (CALL) and found reasons supporting the use of the technology to enhance the limited English proficient student% opportunities for academic success. The following findings on the general effectiveness of CAI suggest implications for the LEP student in particular:[21]

---

20. "The New Information Technology and the Education of Hispanics: The Promise and the Dilemma,N Policy Pamphlet Series 1, The Tomas Rivera Center, Claremont Graduate School, Claremont, CA, 1986.

21. Much of this summary comes from a paper by Patricia Dunkel, Pennsylvania State University, "The Effectiveness Literature on CAI/CALL & Computing: Implications of the Research for Limited English Proficient Learners" (soon to be delivered at TESOL Conference, Miami, FL, April 1987).

First, CAI has been shown, in many settings, to improve academic achievement. A number of studies have documented this, including a 1986 meta-analysis of 28 studies which compared final examination scores in classes using CAI with those using conventional instruction and found higher scores among the CAI students.[22] In applying this analysis to uses of CAI with limited English proficient students, a significant factor is the finding that improvement is greatest with the lowest-achieving student groups.[23] Since LEP students typically demonstrate low achievement rates, the targeting of computer resources to this group would appear to be a logical use of resources.

Secondly, according to other studies, certain types of learning takes place at a faster pace when computers are used.[24] Since LEP students have more to learn, the use of CAI as a tool to speed up their rate of learning seems justified.

Thirdly, and perhaps most importantly, student motivation for learning improves with computer-assisted instruction. While perhaps harder to measure, student motivation is easier to detect in classrooms and is frequently mentioned by computer-using teachers in bilingual or ESL programs. Several reasons for this improved motivation are generally cited:

- The computer is infinitely patient. * A student who has had difficulty mastering a concept, whether it be subject-verb agreement in English grammar, or long division rules in basic mathematics, can go over and over the problem area for as long as necessary for the concept to

22. J.A. Kulik, et al., "Effectiveness of Computer-based Education in Elementary Schools," Computers in Human Behavior, vol. 71, N-o. 1, 1985, pp. 59-74.
23. G. Fisher, "Where CAI is Effective: A Summary of the Research," Electronic Learning, vol. 3, No. 3, November-December 1983, pp. 82-84.
24. J. Orlansky, "Effectiveness of CAI: A Different Finding," Electronic Learning, vol. 3, No. 1, 1983, pp. 58-60.

* The discussion below assumes software which provides, as a minimum, a variety of problems presented, some positive feedback for correct responses (whether it be the simple expression "Good work!" or more elaborate graphics, bells, and whistles employed in some software), and progression to new skills once previous material is mastered.

become clear. If the principle is then understood, the student can continue to practice at his own pace without pressure until the learning truly takes hold. This is drill and practice in its postpositive application —giving the student more time on task, or "seatwork” with the instructional materials.

- Reinforcements positive, nonnegative, and comes immediately on the heels of the response, (not a week later when the graded test or worksheet is handed back). Again, for the LEP student with so much to learn, this immediacy of feedbacks particularly important.

- The computer allows the student to fail privately without shame. Learning only takes place by making mistakes, yet for the LEP student, who is often older than his or her English speaking peers in grade, it can be particularly humiliating to give an incorrect answer orally, in front of the entire class. Since the computer never laughs at anyone, the student can develop the nerve to try and fail in a nonthreatening environment until success finally is achieved.

- The interactive nature of working on a computer gives the student a sense of control and skill. By the very act of booting up the program and entering data on the screen,[25] the student has some Control Of the learning process. The individualized pacing of materials reinforces

25. Conversations with teachers of LEP students indicate that these students have no more difficulty learning how to operate a computer than any other students. Even those who come from environments where they have never before seen a computer adapt quickly to the physical tasks; they are no more computerphobic than other youngsters. Jim Bellino, ESOL teacher, Montgomery County Public Schools, MD, personal communication, Jan. 20, 1987; Nga Duong, Seattle Public Schools, Seattle, WA, personal communication, Jan. 12, 1987, among others.

> this sense of being in charge of one's own learning. The feeling of teaching oneself is a heady experience for any learner. For those stigmatized by the lower status accorded to non-English speakers in our society, the improvements in self-esteem which can follow from being able to take charge can be a first step towards improved academic motivation.

Some of the most promising avenues of computer use for ESL students are in the area of language development through writing. Here, too, general evaluations of computer effectiveness translate to successful applications with the LEP student. For example, IBM's Writing to Read Project focuses on writing as a means to develop literacy skills with prereaders, English-dominant children at the kindergarten and first grade level. The program has been put into place in schools in over 40 some large school districts across the Nation, about one-third of which use the system in Chapter 1 projects. Some teachers who work with LEP children in the Writing to Read Program are particularly impressed by these children's English language skills development through this writing process.[26]

Computers have been hailed as an effective tool for teaching writing to students in the upper elementary and secondary schools as well. In an attempt to see if the improvements in writing skills often found in computer writing projects translate to similar effects when used with Limited English proficient students, the NETWORK, Inc. of And over, Massachusetts, received a Title VII grant for serving gifted and talented elementary students with limited English proficiency through a computer-based writing program. Results from the 1985/1986 school year indicate that the students made

26. At the Franklin Year Round School in Oakland, CA, where 95 percent of the kindergarten students are non-English speakers, the Writing to Read program has helped these youngsters develop word and sound recognition in English. By the midpoint in the school year, almost all the kindergarten children tested at the 1.0 grade level on the California Test of Basic Skills. Dr. Jay Cleckner, Principal, Franklin Year Round School, Oakland, CA, personal communication, December 1986.

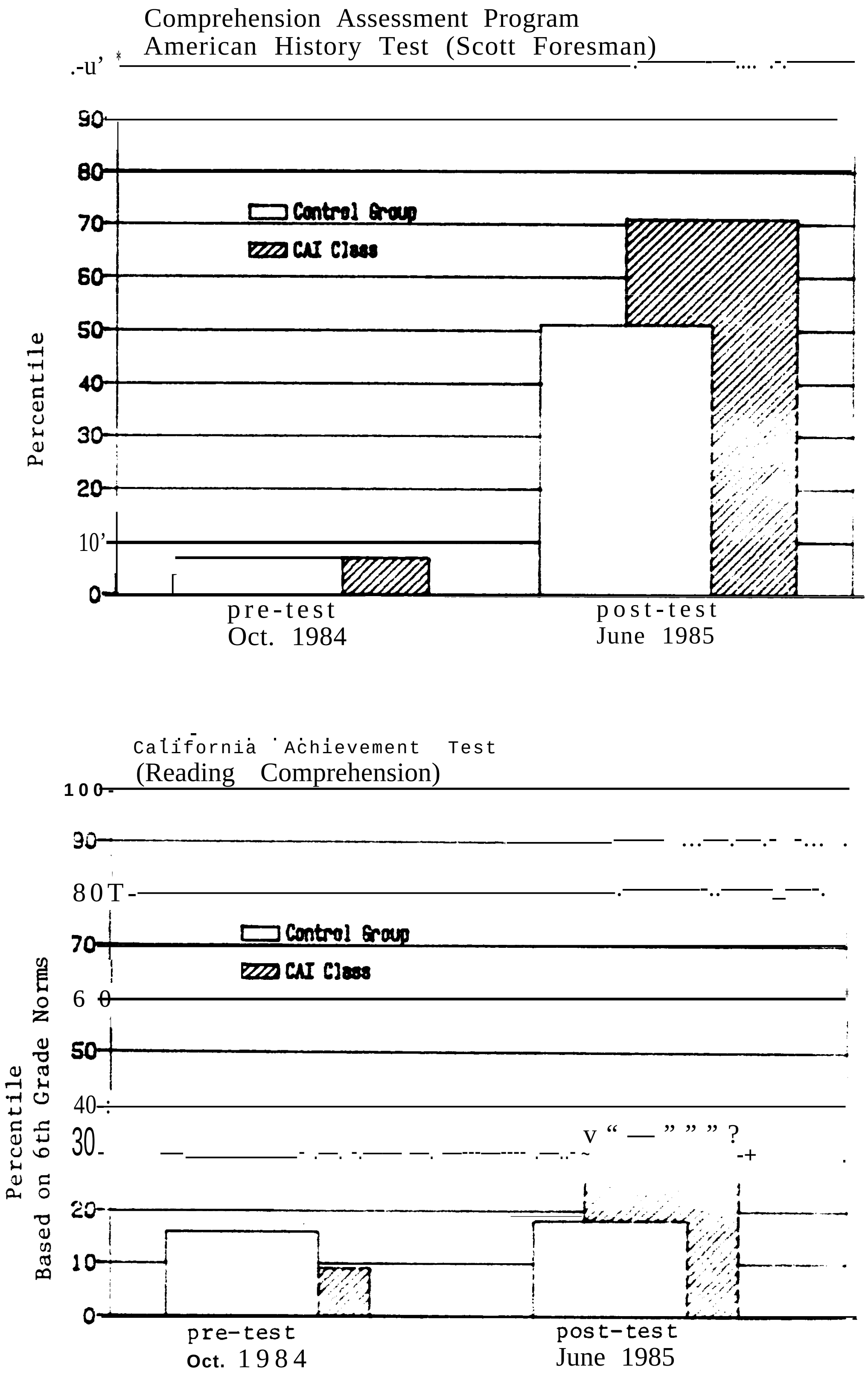
BOX B

In 1983, District 1 of the Seattle Public Schools was awarded a 3-year Title VII grant from the Department of Education to use computer-assisted instruction (CAI) to increase the achievement of limited English proficient students in U.S. history. The CAI materials were developed locally to coordinate with the district curriculum, but adapted to the lower reading skills of their target ESL groups: Vietnamese, Cambodian, and Laotian high school students. The software itself is bilingual, with text and instructions generally in English, and vocabulary in English and the native language. Native language instruction is utilized to explain the operation of the hardware and software; to clarify difficulties with vocabulary, concepts, and factual data; and to link newly-learned concepts with the students' conceptual framework of native language, culture, and history.

Results of the first 2 years of the program (see figure 2) indicated that the experimental group of students at the project school had higher achievement rates in U.S. history and reading comprehension than did those in the comparison group, which was composed of language-matched LEP students who received the traditional U.S. history course without the CAI materials. Although the third year test results are not as dramatic, (the project director attributes this to student variables), the district has demonstrated its satisfaction with the project by funding it out of its own budget at the conclusion of the Title VII grant. Plans are now underway to distribute the project to other schools with similar ESL needs within the District.[1]

1. Nga Duong, Project Director, "Bilingual Computer-Assisted Instruction: Bridge to Academic Excellence," Seattle Public Schools, District No. 1, final report to the U.S. Department of Education, 1986.

FIGURE 2.--Seattle Public Schools, ESEA Title VII Academic Excellence Program Student Achievement Results: Computer Assisted Instruction Class v. Control Group for U.S. History Test and Test of Reading Comprehension



SOURCE: OTA

progress in their writing skills in terms of objective measures such as longer essays, longer and more complex sentences, substitution of punctuation for connective, better choice of words, better subject/verb agreements, and more sophisticated use of verb tenses; as well as demonstrating improved overall control over the writing process in terms of having clearer beginnings and endings, better handling of content, and more fully-developed ideas.[27]

Yet another example of how writing can become a means to break through communication barriers is found in the computer language long distance networks being developed by ESL teachers in several sites across the Nation. The philosophy behind this approach is that, by using the mother tongue in academic settings to accomplish communication tasks valued by the students, writing improves, first in the native language and then in English. In some cases standard writing software is used such as "Applewrite[N] or "Bank Street Writer." As an aide to writing in Spanish, however, a low-cost "bilingual" chip has recently been developed which can replace the character generating chip in the Apple II computer. When this is used with a Spanish language writing software package, students can then write in Spanish with the appropriate accents. A Spanish version of "Fredwriter," the popular public domain writing package, is currently being marketed with this character chip, for under $40.[28]

“De Orilla a Orilla” (From Shore to Shore) is a project linking Latino students in bilingual classes in the United States with sister classes in Puerto Rico. In New Haven Connecticut, a class of 40 fourth graders, predominantly children of Puerto Rican parents, is paired with a similar fourth grade class in Rio Piedras, Puerto Rico. The students communicate exclusively by word processing as they plan, compose, revise, and edit ’texts and messages to their counterparts in the ‘sister school.” They have jointly

27. John Kaiser, Project Director, ‘Special Populations: Serving Limited English Proficient Students With Special Needs Through Writing," performance report to the U.S. Department of Education, January 1987.
28. Al Rogers, Technology Center, San Diego County Public Schools, San Diego, CA, personal communication, Feb. 19, 1987.

BOX C

Another kind of writing program for limited English proficient students, in this case Navajo children in a Chapter 1 program, is being used at Arizonans Kayenta Intermediate School. Kayenta's Chapter 1 teacher, Tess Ritchhart, has developed a program for her students, all of whom speak English as a second language, called the "Language Experience Program." The children, third, fourth, and fifth graders who test at below the 35th percentile on the Iowa Test of Basic Skills Reading and Language scores, come to her Language Experience Classroom for 30 minutes, 5 days a week, where, as she tells them, her job is to make them "as smart in English as you are in Navajo." The children tell the stories they have in their heads, creative tales of subjects that are important to them, writing thereon the classroom microcomputers, then printing and illustrating these 'books/' and sharing them with one another as well as with students outside the Chapter l class. They also tape one another on videocassette as they read their books and present plays they have written. Standardized test results show the childrens' academic gains; perhaps more exciting are the classroom teachers' assessments of their Language Experience students' improvements in self esteem. The teachers report that the youngsters come into the program feeling at a loss in the foreign world of the English-speaking school, but, through the successes they experience in the Language Experience program, come away with a measure of control over this world, confident in their ability to contribute to it. Once they see themselves as special people (bigshots!) in the school, they exhibit improved attitudes toward reading and school in general.

1. Tess Ritchhart, 'Teaching English Using Shakespeare, VCR, Computers, Children's Drama and Student Authoring," materials supplied by Donald R. Kearns, Director, Chapter 1, Arizona Department of Education, 1986.

produced a student newspaper and articles on research topics of interest, such as an investigation of Spanish proverbs, in which they draw upon the cultural resources of their parents and relatives. The goal is the same for the students at both sites: to promote Spanish language literacy through the motivating context of their writing.[29]

Deaf students exhibit many of the same difficulties as do non-English speaking students when learning to communicate in written English, and researchers are studying the effects of using computer writing across local area networks (within a classroom) as a means for this group to break through their barriers of silence.[30] At Gallaudet University in Washington, D.C., a local area network (called ENFI for English Natural Form Instruction) has been developed to teach deaf students to "talk" to one another through instantaneous written communication. Young deaf children from Kendall Elementary Demonstration School use the network once a week to develop and practice their communication skills in writing — the appropriate forms of introducing a topic, maintaining it, 'listening" to what the other person has to say (via reading), responding appropriately, and communicating clearly so they can be understood. In addition to further developing basic skills of communicating (which they are also learning in sign language), they also learn writing skills by sending messages to each other, by writing group stories, commenting on each others' work, and writing back and forth with their teachers. At the college level, entire classes are conducted on the network. As students discuss subject matter or compositions they are working on via the network, they develop

---

29. Anecdotal information from teachers at the sites indicates that striking results come from the English as a second language students being able to communicate with their peers in a Spanish-language dominant society. With their newly-found communicative power has come improved self images, resulting in their becoming more active participants in their regular school classes. Dennis Sayers, Center for Language and Culture in Education, University of Hartford, "International Computer Networks and Bilingual Literacy," unpublished paper, December 1986. For another example of computer networking for literacy and language skills, see reference to Esteban Diaz in the Technical Summary portion of this report.

30. Joy Kreeft Peyton and Trent Batson, 'Computer Networking: Making Connections Between Speech and Writing," ERIC/Clearinghouse on Languages and Linguistics News Bulletin, vol. 10,No. l, September 1986.

and refine their skills in written English (which for them must be learned as a second language), in the same way that a non-English speaking student learns English grammar, idioms, phrasing, and discourse structure by participating in authentic communication that is focused primarily on content rather than form. Before the network was introduced at Gallaudet, hearing impaired students' use of written English in school was confined to structured drills, worksheets, and formal compositions.

Technology's Role in the ESL/Bilingual Teacher Shortage Problem

Another area where technology can play a role in bilingual education is as a means of providing instructional support where qualified teachers are not available to meet student needs. Although figures are not available for overall national shortages in bilingual or ESL teachers (due to variations in defining target students, as well as in State counts, certifying requirements, and emergency hiring procedures), in California alone there is a need for 10,000-11,000 more certified bilingual teachers at the elementary level this school year.[31] Fellowships awarded for graduate study in bilingual education teacher training decreased from 560 in 1980/1981 to 514 in the academic year 1985/1986, and the number of students in degree-oriented programs (pre and inservice teacher and administrator training) decreased from 11,000 to 5,590 in this same period.[32] Fewer than half the States require certification of ESL or Bilingual Education teachers, although 16 States have legislative initiatives under development to revise or upgrade certification requirements in ESL or Bilingual Education.[33]

31. Gold, op. cit.
32. Irwin, et al., op. cit.
33. A recent study of certification of language educators (unpublished draft) showed that 19 States require certification of English as a second language teachers, and eight States require certification for bilingual education teachers. Endorsement, which is defined in the study as State recognition of the right of an individual to teach a certain specialty area although his or her certification is in another specialty area, is required in 11 states for English as a second language teachers, and in 17 States for bilingual education teachers. Endorsements are usually granted for completion of a minimum number of credit hours, generally substantially fewer than the required minimum for specialty area certification. Five States provided for emergency or temporary

States and districts are turning to technology as one means of providing resources where fully certified teachers are not available. Again, ESL and bilingual education programs may benefit from the example of technological approaches to meeting teacher shortages in other areas. For example, Utah has developed an innovative instructional program combining television and computer technologies, called the Distance Accelerated Learning Program (DALP) to teach Spanish across widely scattered rural sites across the State, in schools where certified teachers are not available. Students in grades 6-10 in 45 schools in 26 districts across Utah (and subscribing Districts in 5 other States) are provided instruction via this combination of technologies. Research results show that the program has met its goal of covering 2 years of Spanish instruction in one school year. Based on the program's success, the project designers are now working on turning the program around, to provide English language instruction to native Spanish-speaking high school students where similar teacher shortages preclude ESL instruction. The interactive computer activities, classroom management techniques, and video/audio components will be structured as in the original Spanish instructional program.[34]

The interactive videodisc is another technology that shows promise, as it can take the best of a scarce educational resource — good teaching — and multiply the instructional impact, reaching a much wider audience. Videodiscs can also provide the personalized pacing and cognitive reinforcements found in advanced computer programs. With dual audio tracks, the use of video to present language use in dramatic context, and branching capabilities, interactive videodiscs are now being developed to

---

certification in the English as a second language/Bilingual teaching areas. Karen Willetts, Center for Applied Linguistics, unpublished paper, 1986.

34. Videotaped instruction is transmitted by satellite for 40 minute sessions five times every 2 weeks. On nonbroadcast days the students work with voice-synthesized vocabulary drills on the computer, and with traditional written instructional materials. Classrooms can be managed by non-Spanish speaking teachers or classroom aides. Evaluation results have been positive on measures of listening, reading, and oral proficiency skills. Kenneth L. Neal, Coordinator, Instructional Technologies Unit Utah State Office of Education, Office of Curriculum and Instruction, materials and personal communication, 1987.

BOX D

“Skillpac: English for Industry” is an interactive videodisc that teaches English language and cultural skills in a vocational context appropriate to the petroleum, construction, and other industries. While learning about such job skills as inspecting shipments, maintenance of equipment, reading meters and gauges, planning meetings, and dealing with industrial accidents, the learner also is guided from a low to intermediate level of English proficiency to a relatively advanced level, with focus on such language functions as greetings, introductions, and leave takings; following oral and written directions; asking for and giving clarification; making small talk; describing and explaining; analyzing and responding; comparing and contrasting; using the telephone; and reporting orally and in writing, among other uses of language in context. The videodisc, originally designed for petroleum workers in Indonesia, has instructional assistance in Indonesian. In the United States, different versions for native Spanish and Portuguese speakers have been used with displaced workers in Massachusetts. These materials provide not only visual images but also opportunities for listening in context as required for effective language learning, and maybe equally useful with non-English speaking high school students in vocational education programs.[1]

---

1. Allene Guss Grognet, “Skillpac: English for Industry,” Center for Applied Linguistics, Washington, DC, materials and personal conversation, January 1987.

provide foreign language training for the military.[35] Other videodiscs just coming on ‘he market, such as Optical Data Corporation’s "Principals of Biology" and ‘Physical Science" videodiscs, provide bilingual audio tracks. These comprehensive science curriculum materials can assist the non-Spanish speaking teacher who would otherwise have difficulty teaching science concepts to his or her English deficient students.

BARRIERS TO FULLER IMPLEMENTATION OF TECHNOLOGY

The factors which are barriers to fuller implementation of technology in bilingual education are similar to the factors which hinder educational technology in general. They are the lack of quality software, the need for further teacher training, restricted funding sources, and gaps in educational research.

The Software Problem

Educators have lamented that good-quality software is one of the missing links to full utilization of microcomputers in the schools. Nevertheless, in the last few years many excellent programs have been developed in the fields of mathematics, language arts, social studies, and the sciences, as well as utility software packages such as word processing, databases, and spreadsheets which can be used in various subject areas. In the field of bilingual education and English as a second language, however, the software picture is not as encouraging as in other academic areas, both in terms of quantity and quality. For example, the 1988-1987 edition of The Educational Software Selector (TESS)[36] lists only 34 entries under ESL out of a total 6,838 instructional products in the directory (Table 2). Furthermore, although the 1985 guide to ‘Microcomputer

35. Brigham Young University, CAI/CALL Research, materials provided by Frank Otto, December 1986.
36. The Educational Software Selector, 1986-87 edition, EPIE Institute (Southampton New York, Teachers College Press).

Table 2

Distribution of Commercial Software Products by Individual Subject Matter Areas

Subject Matter	Number of Software Products
Agriculture	16
Aviation	12
Business	189
Comprehensive[1]	536
Computers[2]	306
Driver Education	
Early Learning-preschool	10:
English-Language Arts	751
English as a Second Language	34
Fine Arts	172
Foreign Language	305
Guidance	110
Health	92
Home Economics	113
Industrial Arts	57
Logic and Problem Solving	111
Math	1,646
Medicine	67
Miscellaneous	27
Physical Education	37
Reading	636
Religion	24
Science	1,013
Social Science	375

1. Generic software that **can be used** in all subjects.
2. Computer programming and computer literacy.

Source: **Based on data extracted from** The Educational Software Selector (TESS) Database, **May** 1986, personal communication, Bob Haven, Educational Products Information Exchange (EPIE), Water Mill, N.Y. Note: Haven estimates that a very small proportion **of** the software listed in TESS could easily be used by limited English proficient students.

Courseware for Bilingual Education"[37] has total of 466 entries, many of these are standard software programs in reading, language arts, mathematics, and counseling — materials which, while possibly usable in an ESL setting, have not been specifically developed for use with limited English proficient students. Consequently, teachers of limited English proficient students are in a situation similar to that experienced by special education teachers: taking general purpose software and adapting it for use, or trying to use it as is, for their students with special needs. As mentioned earlier, teachers often hesitate to use software written in English with their LEP students, thereby limiting the students' access to computers.

Although some software used with LEP students employs the concept of "sheltered English" (see definition section above) in subjects such as science and social studies, this type of software is rare.[38]

Software developers and distributors, as well as educators looking for materials suitable for LEP students, emphasize that the bilingual education/English as a second language market is a thin one, discouraging the investment of development dollars necessary to create state-of-the-art software to suit the varying language needs across the K-12 grade spectrum. This difficulty is further compounded by publishers' concern over the current uncertainties of bilingual education as an accepted educational approach for LEP students, due to such political questions as California's recently enacted Proposition 63, interpreted by some as an "English only" mandate. Much software used in classes is teacher-designed, with resulting mixed quality. Some exciting work is coming

---

37. Deborah Sauve, National Clearing house for Bilingual Education, InterAmerica Research Associates, "Guide to Microcomputer Courseware for Bilingual Education," 1985.
38. Lawrence Stolurow, Center for Education Experimentation, Development, and Evaluation, College of Education, The University of Iowa, Iowa City, IA, personal communication, Feb. 17, 1987.

BOX E

The Houston independent School District serves 42,000 limited English proficient students, a high percentage of whom are at the lower elementary and elementary school levels and who also have severe academic problems. The district staff searched among available English as a second language software for units appropriate for this population, and found that many publishers took reading software and called it ESL, while others simply made word-for-word translations of existing language arts software, which the Houston staff found equally unsatisfactory. They looked particularly for software which contained audio output, as they felt this was especially important for their large preliterate population of LEP youngsters. When they found little to meet their specifications, they approached major software publishers and invited them to produce ESL software meeting their specifications; the results were bids beyond their budget, on systems requiring large investments in new hardware. As a result, Houston developed its own ESL software over a 2-year time period, involving a staff of 15 and a cost of approximately $1 million. The product includes 14 instructional units of computer-assisted instruction, utilizing digitized speech playback of human voices of all types (male, female, child, grandparent) and in dialog conservation, all in English. The software has been extensively tested and implement across the district in existing Chapter 1 programs serving the LEP student population.[1]

---

1. The software, called "Harmony," works with the Euphonies system, an audio output device and card for use with the Apple computer. It is now marketed by Jostens Learning System and the royalties have already repaid Houston's initial investment in the product development. Dan Daniels, Executive Director, Technology Department, Houston Independent School District, Houston, TX, personal communication, Feb. 13, 1987.

out of university settings, where industry contributions of equipment and resources has begun to stimulate courseware development, but the applications in bilingual and ESL materials remain a small piece of the overall effort.

Allied with the problem of quality is the problem of distribution. The software that is produced by teachers, whether on their own or with Federal funding, as in Title VII projects, may sit in the teacher% desk drawer, its existence and potential hidden. Furthermore, although the National Clearinghouse for Bilingual Education has a contract to maintain a database of all materials; including software produced under the Office of Bilingual Education and Minority Language Affairs (OBEMLA) funding, it does not have the capacity to evaluate, reproduce, or distribute this material to interested schools who might find it useful.[39]

Teacher Training

For teachers to be able to use technology effectively and creatively, they need appropriate training. For most teachers of LEP students, technology training, when available, has mainly concentrated on computer literacy and the use of very specific types of materials used in the instruction of the LEP student.[40] There is a general agreement among educators that teachers working with Limited English proficient students need more training in the use of computers to aid instruction.[41] They need experience with identifying and evaluating software, information on where to go to find appropriate software, and familiarity with the authoring software which provides a shell

---

39. As one means of addressing this need, Ohio University's Program of Intensive English and the Department of Linguistics have set up a Clearinghouse for ESL Public Domain Software. Users can purchase any disc listed in the catalog for the price of reproduction and mailing (about $5.00-$7.00) or they may trade a piece of software they have designed for another disc. The catalog currently lists 18 titles, but the clearinghouse coordinator is optimistic that interest in the field will generate many more listings in the future. Jeffrey Magato, ESL Software Clearinghouse, personal communication, January 1987.
40. Ron Saunders, COMSIS, personal communication, Feb. 20, 1987.
41. "The New Information Technology and the Education of Hispanics: The Promise and the Dilemma," op. cit.

for them to fill with their own materials based on their curriculum and the students' needs. They need to develop a sense of mastery over the computer which allows them to understand and apply its potential in their instructional activities.

Research

OBEMLA's Office of Research has outlined many areas where better research data is needed to assess the impact of various educational treatments of limited English proficient students. The role technology has or can play in these various educational treatments needs to be explored as well. Given the scarce resources (dollars and teachers) available to serve the large educational needs of LEP students, are distance learning and CAI/CALL cost effective uses of scarce resources? And, more generally:

- How do people learn a second language? What cultural differences come into play in language learning environments? What is the effect of peer learning? Of motivation? How can technology be used to enrich what research says about the importance of listening skills, comprehensible input, language learned in context, and content-based language instruction? Blending the expertise of linguists, cognitive researchers, child development specialists, sociologists, and technologists would enrich the research well beyond what any individual field can offer on its own.

- What can we learn from longitudinal research? Most ESL studies look at results after one to three years of treatment, yet the complex analysis of language acquisition, and important spillover into other academic areas, may need fuller follow-up than this, in technology treatments as well as in more traditional educational approaches.

Funding

As in all educational activities, cost is a factor. For technology, it is a big factor. Although the cost of computing power has decreased dramatically (an investment of $2,000 to $3,000 today will secure a microcomputer with peripherals which can provide the capability offered only by a mainframe computer of 10 years ago),[42] and although there are over a million personal computers in K-12 schools today, technology remains a heavy investment for any school system, whether it be the startup costs of hardware, or costs of software, maintenance, communication lines, teacher training, improved school security to house expensive equipment, insurance, and so on. It takes dollars to remove the roadblocks to implementation listed above. If innovative educational materials are to be developed which utilize the full potential of current technology (e.g., expanded use of voice synthesizers for audio components in language training or the development of interactive videodiscs), heavy investments will need to be made.[43] For school systems to do the necessary planning and create programs targeted to district-wide approaches to LEP educational needs will cost them both time and dollars that might otherwise be spent on other competing educational needs.

SUMMARY AND IMPLICATIONS FOR FEDERAL POLICY

Findings concerning limited English proficient students and educational technology are summarized below, followed by policy implications raised by these findings.

The population of limited English proficient students is a large one, and will continue to grow in the decade ahead. These students present a significant challenge to

42. Dunkel, op. cit.
43. For example, the Skillpac videodisc described above cost over $300,000 to create, according to estimates of its developers. The funding for this project came from a private business that saw the cost as a worthwhile investment asa means of developing a skilled work force. Allene Guss Grognet, Center for Applied Linguistics, personal communication, February 1987.

the education establishment, since they must learn more in school (the normal academic skills along with English) than do their English-speaking peers. At present, the educational needs of large numbers of these students are not being met, as evidenced by their disproportionately high failure and school dropout rates. Consequently, there is a clear and pressing need to optimize the reach of programs and services for students handicapped by their English language deficiencies.

Technology can play a role in programs for LEP students, as well as bridge their transition into the educational mainstream. Where technology is being used, LEP students are assisted in the learning of basic skills and acquisition of English. Programs that utilize computer-based instruction find that the technology can provide immediacy of reinforcement, positive feedback, extensive practice, individualized pacing, and a greater degree of student control over the learning process. Advances in technological capability add dimensions such as graphics, sound, music, and video that can provide a broader real-life context to language learning. Newly affordable digitized speech generators can play an important role in the development of oral language skills.

There is one particular area where computers seem to be making a special impact on language development — that is in the field of writing. Word processing capabilities and in some instances, local or long-distance networking capabilities of computer-based technology, are being used to encourage LEP students to write and communicate more effectively in highly functional contexts, both in their native language and in English. When used in this context, the computer can provide a means For students to breakout of the traditional mode of thinking, to enhance their sense of mastery, and to enrich the learning experience by providing access to role models and speakers from their native culture.

With a shortage in the number of trained bilingual or ESL teachers, some States and districts are finding that technology can provide one means of addressing this problem.

Instruction through distance learning, electronic networks, and computer-based instructional systems or combinations of these are being tried.

Finally, the potential for computer use exists and in some sites is operational, the general picture reveals that technology is still a small part of bilingual/ESL education. Currently, only one in five bilingual or ESL teachers uses computers in working with their LEP students. Among possible reasons for this low level of usage are numbers of computers available in the school and who has access to them (in Chapter 1 programs computers are used for ESL instruction half as often as in other instructional computer uses) lack of appropriate courseware or teacher awareness of its availability and possible usefulness, and absence of school policy promoting computer-assisted language learning for this group of students.

These findings raise several policy implications and suggest next steps and further directions which might be pursued.

Research can play a role in defining the problem of adequately serving this growing percentage of American students and identifying possible solutions. Federal, State, and local policymakers need abetter fix on the numbers of LEP students in school today and coming in tomorrow, on the ways that technology can serve these students, the access they have to appropriate technology, and ways current roadblocks to access could be removed. Current research may not be adequate to this need.

Federally funded projects have produced some exemplary programs using technology to serve LEP students. This suggests that Title VII funds might be targeted to support more and expanded demonstration projects that point to meeting local needs through technology.

New advances in technology create even greater capabilities for meeting needs of this specialized group of students. Seed money investments by the Federal Government might be considered to develop state-of-the-art software that fully utilizes the capabilities of computers, speech synthesis, interactive videodiscs, compacts discs, and other devices which can be used for teaching limited English proficient students.

Evidence that currently available materials (e.g., good computer courseware) are not adequately known and/or readily made available to schools suggest that the need for dissemination is clear. Consideration should be given to providing expanding resources for evaluation, duplication, and dissemination of public domain ESL software.

Given the current interest and experimentation with distance learning, policies might be adopted and investments made to encourage the use of distance learning strategies to meet common educational needs of limited English proficient students, using satellite, cable, interactive television, and other forms of technologies to share instruction across and among schools, districts, or States.

Teacher training, both preservice and inservice, could be expanded to increase bilingual or ESL teachers' understanding of technology as a tool to enhance LEP student learning and help remove barriers to equal access to computers in schools.

Finally, it should be understood that technology is only one means, though a powerful one, to improve the educational service provided to the Nation's growing cohort of limited English proficient students. Children who have such special needs require special attention; as a high risk educational group, extraordinary resources may be called for. Education, a labor-intensive industry, can be supplemented by the resources technology provides, but this supplement cannot ever take the place of a dedicated and talented teacher. The classroom teacher whose students are limited in their ability to communicate in English should be provided the most efficient tools of the trade in order to help these children move into the full mainstream of the educational system.

APPENDIX A

EDUCATIONAL TECHNOLOGY: A TECHNICAL SUMMARY

APPENDIX A

EDUCATIONAL TECHNOLOGY: A TECHNICAL SUMMARY

INTRODUCTION: THE ELECTRONICS ENVIRONMENT

From “intelligent” heart pacemakers to fully computerized combat fighter airplanes, today electronic information technology has application in almost every arena of human activity. Indeed, it is now impossible to imagine how banking, communications, defense, manufacturing, and medicine ever could have functioned without the vast network of electronics that has been installed in the last 25 years.

A vast and expanding diversity of such applications seems to be changing the relationship between society and technology. Increasingly, people are required to communicate with electronic devices. And it is not uncommon for electronic devices to interact with people, calling them by name, asking them to do things, or thanking them. Throughout their lives children now in school will encounter thousands of such technologies.

The fundamental agent of this change is the technology of microelectronics, which makes possible the miniaturization of electronic circuitry onto tiny microchips. * The maxi m “smaller, faster, cheaper’’ has had broad implications. As more electronic devices are compressed into smaller spaces, their operation takes less time. As electronic information technology gets faster, it also becomes capable of a higher density of communication. Together, these two capabilities allow the development of smaller and smaller machines of increasing complexity and power. And as these become cheaper, due

* Microchips, ‘chips’ or, more properly, integrated circuits~ are collections of electronic components such as transistors or resistors, compressed into a single miniature silicon dioxide wafer less than the size of a small fingernail. Over the past two decades the number of components capable of being integrated into a single chip has grown from tens to millions.

to the falling cost of mass producing microelectronic components, greater general access to increasingly powerful machines becomes possible. At the same time, adding electronic components to traditionally mechanical processes is also encouraged by economies of scale and reliability. This means that putting a microprocessor in a photographic camera, for instance, can increase its capabilities while simultaneously decreasing its price.

Today, microelectronic information technology can be found in automobiles, ovens, credit cards, refrigerators, greeting cards, robots, satellites, talking toys, televisions, telephones, and even blackboards that play notes when touched or that can print out their contents on paper after class. And some electronic technologies, like calculators, have become commonplace for the student population to use at home or in school.

As an indication of how rapid the development of electronic products has become, an Electronics Industries Association publication estimates that nearly half the consumer electronics products on the market today have been introduced within just the past 10 years. [1]

Consumer video technology is another important outcome of microelectronics development. In early 1986, the percentage of American TV homes with VCRs was well above 30 percent, and by the end of the year, this figure was expected to pass 40 percent.[2]

But perhaps the most important development of microelectronics is the computer on a chip, the microprocessor. * Microprocessor chips, which can be used in calculators, watches, and other automatic devices, when put together with memory chips, input-output circuitry, a keyboard and a screen or printer, can become microcomputers.

---

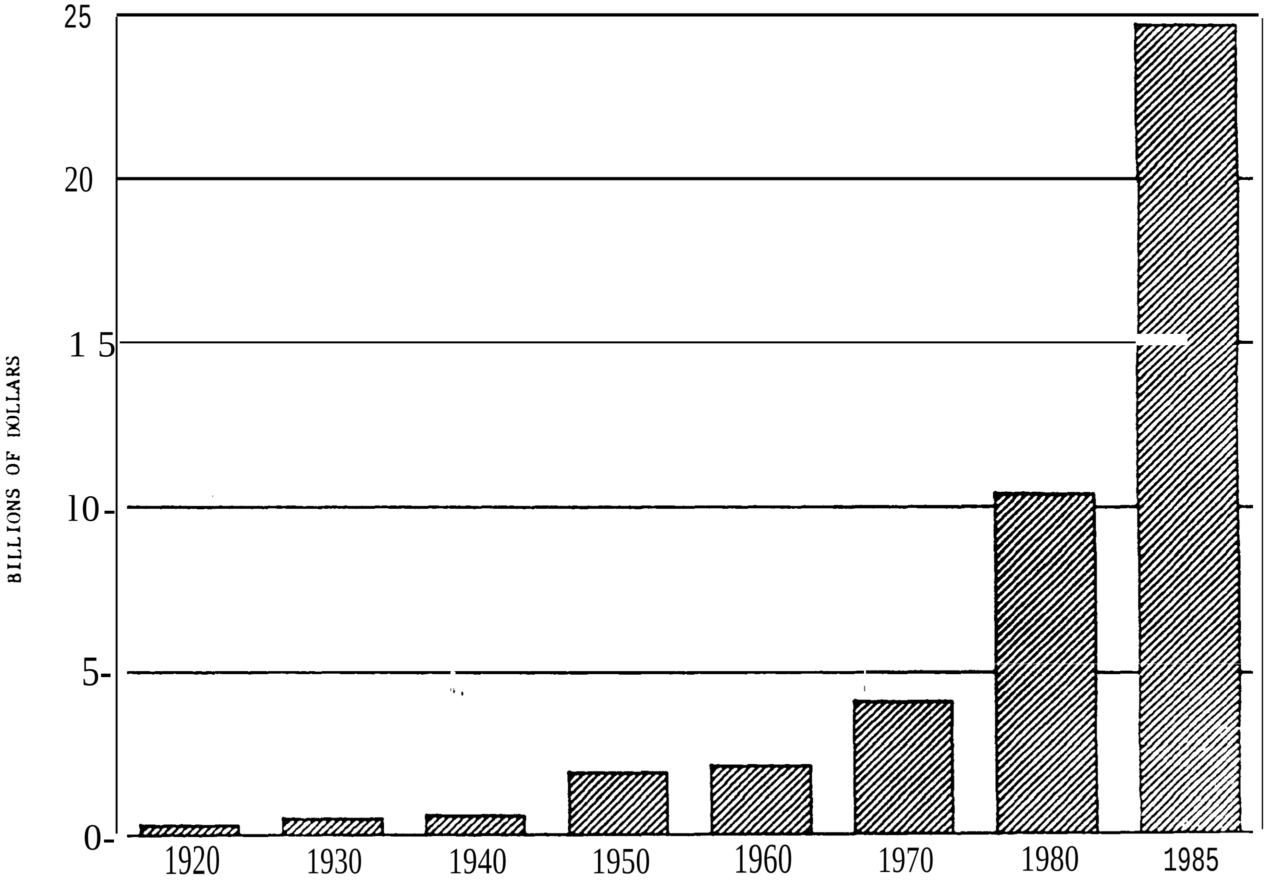
1. Electronic Industries Association, Consumer Electronics Annual Review, 1986, p. 17.

2. Ibid., p. 8.

* Microprocessors contain all the normal components of the central processing unit of a regular mainframe computer — accumulator, registers, stack, and arithmetic logic — on one microelectronic integrated circuit, or chip.

FIGURE 1

CONSUMER ELECTRONICS MARKET
Total U.S. Market



SOURCE : Electronic Industries Association, Consumer Electronics Annual Review, 1986.

It is estimated that, by the end of 1985, 15 percent of all American homes had microcomputers.[3] In one survey, it was found that by mid-year 1985) about one out of five pre-teen or teenage children had access to microcomputers in their homes.[4]

Education, often criticized for adapting slowly to its changing technological environment, has not been left out of this revolution: during the 1985-1986 school year, elementary and secondary schools in the United States spent between $400 and $600 million on computer hardware, and another $130 to $150 million on software. Now less than 5 percent of all schools are without at least one microcomputer.[5]

Falling costs, enhanced microminiaturization, and increased speed of components has encouraged the development of more complex microcomputers.** However, the first commercially available microcomputers, and most microcomputers still used in homes and schools today, have 8-bit microprocessors.*** Since their introduction a decade ago, two further generations of microcomputers — based on 16-bit and 32-bit microprocessors — have been developed, and many new peripheral devices which can enhance and extend the microcomputer's abilities have also become available.

---

3. Ibid., p.59.
4. Corporation for Public Broadcasting, Use of Electronic Information Technologies for Non-School Learning in American Households (1986) p.7.
5. Fran Reinhold, 'Computing in America — 1986 Annual Survey," Electronic Learning, vol.6, No. Z, October 1986, p.27.

** Even though extremely inexpensive microcomputers with limited memory have been available for as little as $100. — (e.g., Sinclair, Vic 20) – consumers and other users such as schools, have generally rejected them in favor of the increased capacities of micro computers with more memory and other enhancements such as diskette drives.

*** Eight-bit, 16-bit and 32-bit characterizations refer to the width of data pathof a given microprocessor and determines the number of instructions that a microprocessor 'can carry out and the amount of memory it can address. By 1977, two 8-bit microprocessor chips had emerged as the principal industry leaders, Zilog's 2-80, which was used by Tandy's TRS-80, and MOS Technology's 6502, which is at the heart of Apple II, Atari and Commodore computers. In the early 1980s, a new family of computers was introduced with 16-bit data paths. IBM% PC, XT, and a host of compatible computers are based on Intel% 8088 family of microcomputer chips and, by 1985, had become the de facto standard for small business, and many higher education applications. More recently, the Apple Macintosh, the Commodore Amiga, and new computers by Tandy, Atari, and WICAT, use Motorola 68000 chips, which have 32-bit internal architecture. And IBM has also introduced a 32-bit chip called the Intel 80386 for its AT computer. The advantage in speed and flexibility of these wider data path processors translates into much faster computations, more detailed graphics, and environments that can anticipate the user's necessities (user friendliness).

Today, in corporate, business, and industry settings, such second and third generation microcomputers commonly run multiple programs at once, share programs and data with other computers in Local Area Networks, communicate over telephone lines with worldwide resources, and have the ability to create and print multicolored graphics. Due to constant reduction in the size of components, a computer as powerful as those which used to require a large air-conditioned room can be carried in a briefcase. Today microcomputers are approaching the capacity of full-sized computers of two decades ago, including the ability to have a number of terminals (keyboards with video screens) run from the same computer.

Meanwhile, full-sized computers or "mainframes" have also been transformed by microtechnology, increasing their memory capacity and speed of operation, allowing them to store vast amounts of data and analyze it at speeds of up to 160,000 times faster than a typical personal microcomputer.[6] And whereas very few school children will ever see a large mainframe computer, they may well access a database contained in one from a personal computer at home or at school or interact with one at a bank. Moreover, research in artificial intelligence, expert systems, and cognitive science is beginning to have an effect on microcomputer programs used in schools.[7]

Computer technology is based on binary switching circuitry. This means that all information is processed as discrete yes/no or on/off bits. Other electronic devices such as radio and television were developed as analog technologies which processed information as electronic waves. Each time these waves, or signals, pass through the air, a wire or other electronic component of transmission, storage, or processing system, they acquire "noise" and lose some of their character or fidelity. A major advantage of digital technology is that no loss of signal is encountered, no matter how much processing

6. Richard A. Jenkins, Supercomputers of Today and Tomorrow, (Blue Ridge Summit, Pa: TAB Books Inc., 1986), p. 18.
7. Lauren B. Resnick and Ann Johnson, "Learning Theory as a Guide to Educational Software Development," unpublished presentation to Technology in Education in 2020 panel, October 17, 1986, p. 10.

circuitry it passes through. Further, after analog signals are transformed into digital information, they can be manipulated, processed, and stored much more accurately using computer technology. Compact disc (CD), digital televisions, and other digital storage technologies, including telephones, are dropping in cost and increasing in use precisely because of the move from analog to digital signal processing.

ELECTRONICS IN THE CLASSROOM: COMPUTER HARDWARE

Of an estimated 1,036,000 personal computers in public schools today, some 70 percent are Apple or Commodore, which are 8-bit computers with limited graphics capability (a maximum of 16 colors, with a resolultion of about half the detail of a television image and an average of 64 kilobytes of memory.)[8]

As can be seen in Table 1, the overwhelming percentage of computers used in all schools are of this type. It can also be seen that the percentage of 16-bit computers— all IBM computers and a significant percentage of Radio Shack computers— is greater in the higher grades. In light of the predominance of 16- and 32-bit computers in business, it does not appear from these numbers that schools are hurrying to purchase computers with more power and capability.

However, this situation could change in the future. In its Fifth Annual Report, TALMIS contends that 8-bit technology predominates. At the same time, the TALMIS report points out that schools: [9]

> . . . are very aware of the advances taking place both in computer technology and in associated areas such as mass storage, interactive video, communications, and networking. While using mostly supplementary single-concept CAI (Computer Aided Instruction) and generic tool software to support the instructional program, the schools are also aware of the power of the computer to manage and deliver truly individualized instruction as well as to access and manipulate vast amounts of information. If the school

8. Data provided by Market Data Retrieval, Inc., under contract to OTA.
9. TALMIS Inc., The K-12 Market for Microcomputer & Software (New York: 1985), p.s.

Table 1

PERCENTAGE OF BRANDS IN SCHOOLS OF COMPUTERS, BY GRADE

1986

Schools	Apple	Commodore	IBM	Radio Shack	Others
Elementary	62.2	15.0	3.1	9.8	9.9
Junior High	59.5	14.6	3.8	15.1	6.9
Senior High	53*7	8.7	10.2	20.1	7.3
TOTAL	58.3	12.3	6.3	14.6	8.5
1985					
Elementary	58.0	16.6	2.2	11.1	12.1
Junior High	55.7	16.5	3.1	16.5	8.2
Senior High	51.4	10.0	8.2	22.0	8.3
TOTAL	54.8	13.8	5.0	16.5	9.9
1984					
Elementary	52.7	18.3	1.3	13.8	13.9
Junior High	50.7	17.5	1.9	20.5	9.4
Senior High	48.4	11.5	5.6	25.2	9.2
TOTAL	50.4	15.2	3.5	19.8	11.2

Source: Market Data Retrieval 1986.

of the future is one in which computers are closely integrated into the instructional process, then the schools will have to make the transition to more powerful equipment better able to support extensive instructional use.

One factor that may affect the introduction or incorporation of more powerful computers in schools is that microcomputer technology does not wear out. Aside from the cathode ray tube (CRT) in video monitors, keyboards that are abused, and the mechanical parts in diskette drives, microcomputers are virtually impervious to wear. Another factor may be that there is more educational software written for 8-bit computers than other types of systems. Even though 16-bit computers are now competitive with high end 8-bit computers in price, there is less established educational computer software available for them. One possible remedy for this is that manufacturers build in "downward compatibility," the ability for new machines to use and operate most software written for earlier models. The Apple IIgs is an example of this approach; however, development costs must be greatly increased to achieve such comparability.

A limited number of schools and districts have opted to invest in a single minicomputer and terminals, rather than multiple microcomputers, for instruction delivery. Such systems, sometimes called Integrated Learning Systems, generally have a central computer unit, about the size of a dishwasher, located in a secure area. Cables extend to one or more classrooms in the school where a computer laboratory with 20 or 30 terminals can be used by any number of students. Remote terminals can also be connected by telephone lines, allowing more than one school to use the system at one time. The benefit of such a centralized system is that it can store many different programs relating to various curricula as well as automatically accumulate student test scores and progress indicators. It is then able to compile and print out individual and group reports. Another benefit is that teachers do not have to be trained cooperate the computer themselves.

There is also a negative side to a centralized system. Programs tend to be unadorned alpha-numeric drill and practice lessons because graphics, especially color graphics, and sound require large amounts of processing time for the central computer. Since the computer has to manage many terminals all at the same time, the speed of its responses can be slower than with dedicated microcomputers, if more than the designated number of terminals are used, which can cause student frustration. Such systems also tend to be more expensive and less flexible than similarly equipped microcomputer labs due to the cost of installing cables, modems, and computer hardware. A typical installation of 30 terminals and software to run a mathematics program cost between $80,000 and $130,000.[10] One school district that installed them ‘n four schools estimated their costs at about 50 percent more than a corresponding microcomputer-based system.[11]

In many schools, however, there is an increasing use of Local Area Networks (LANs), where networks of microcomputers are connected together within a school or laboratory, to provide shared mass storage (disc drives), printers, programs, or other devices like plotters. These systems are similar to but unlike the minicomputer systems, in that the local computer uses its own central processing unit for activities such as computation and word processing, and only accesses shared resources for transferring files, programs or data. Using a single hard disc drive with 20-30 million characters of storage capacity to serve multiple work stations can be very helpful to the teacher who, in a laboratory without networking, must spend a lot of time organizing diskettes, which can usually store only 300,000 to 400,000 characters, and require changing frequently.

---

10. Steve Petix, “Computers Turn Doubting Educators into True Believers,” The Daily Californian, July 13, 1985.

11. Robert O. Slater and William F. Lynch, “Minis Versus Micros: Points to Ponder Before You Buy More Computers,” The American School Board Journal, March 1986, p. 35.

Peripherals

Peripheral devices such as floppy disc drives, color monitors, and printers change the capabilities of computer systems dramatically. For instance, disc drives can load programs or data into the main memory of a microcomputer many times faster than from cassette tape and also have the advantage of random access. Color can be a very effective and educational device; software writers often use it to enhance the meaning and attractiveness of instructional programs. Windows allow more than one screen of text to be examined at once. This ability can aid in programming and allows banners to be created or large spreadsheets to be studied. Once a child has created a composition using a word processor, there is a significant difference between having it printed out on paper and simply looking at it on a computer screen. Some schools are using printers to accomplish desk-top publishing and disseminate classroom or school newspapers. Although floppy disc drives have become standard with most microcomputer installations, the number of printers or color monitors in use has not matched the growth of microcomputers installed in schools.[12]

Instructional effectiveness may also be affected by other peripheral devices such as tablets for graphics, light pens, track balls, mice, CD-ROM, videodiscs, robotics devices, and a number of scientific measurement devices like thermometers, pressure, and sound sensors. Software written for use with such scientific instruments can enable the computer to automatically plot changes over time and gives science teachers new capabilities when conducting scientific experiments. For example, a computer may be left on overnight to monitor changes in temperature in a terarium or a rat's cage.

12. TALMIS, op. cit., p. 66.

CD-ROM

CD-ROM is a laser-optical technology that can store and retrieve up to 550 megabytes of digital information — the equivalent of more than 100,000 pages of text — on a single 5 1/4 inch disc. For instance, with a CD-ROM player used as a peripheral, a microcomputer can access any entry in the entire 20 volume Grolier Encyclopedia from a single CD-ROM disc.[13]

Used in libraries, the CD-ROM can become a valuable resource for computerized searches of large databases such as the Library of Congress card catalog, Books in Print, Reader's Guide to Periodicals, and many other references now becoming available in this highly compact medium.

CD/I

Another new integrated interactive system, although not yet available, is based on Compact Disc (CD) technology. The Compact Disc/Interactive (CD/1), although announced in 1986, will not come to market until fall of 1987. it will be similar to a CD player and able to play regular stereo audio CD discs, but it will also store still video pictures, animation, text, and software on the same disc. It will have a computer built in and require only the addition of a television set. One writer projects wide applications for education:

> CD/I has the potential to cover the entire spectrum of the general school curriculum. Science, math, history, reading and foreign language will each have a CD/I series. One of the most common drawbacks of using computers to teach general subjects is lack of adequate audio and pictures. CD/I will solve this problem at a hardware price that will be competitive with the Apple line of computers. 14

13. Bradford N. Dixon, "The Grolier Electronic Encyclopedia," CD-ROM Review, vol. 1, No. 1, October 1986, p. 10.
14. Bryan Brewer, "Compact Disc/Interactive (CD/l)," CD-ROM Review, vol. 1, No. 1, October 1986, p. 56.

Interactive Videodisc

Using a videodisc player as a peripheral to a computer creates an interactive video system which can be used to provide television quality pictures and sound as components in an interactive simulation or as part of individualized instruction. The computer calls up moving sequences, still images, audio from one or both audio tracks, on demand, according to its program, which can itself be stored on the videodisc. A total of one half hour of motion video, or 54,000 individual frames, can be stored on each side of a videodisc.

Musical Devices

Computers can also be used to control a growing number of musical synthesizers with a new standardized protocol, called MIDI. The MIDI protocol can be used to record the keystrokes of a keyboard player and then manipulate them and play them back in any number of musical voices. Now children can learn musical theory and play compositions using a computer to help them.

Modems

Modems allow computers to use telephone lines to transfer messages, files, and sometimes programs, from one computer to another. A number of public information services, like CompuServe and The Source have special electronic bulletin boards for students and teachers who have access to computers, modems, and telephone lines.

In some cases, students can conduct research by accessing an online encyclopedia, or swap information with students in other areas of the country using one of a number of private bulletin board systems, or specialized online systems like the Big Apple Bulletin Board which is run by the New York City Board of Education. And in certain demonstration programs, some students can communicate through modem connection from their homes to their schools.

The ease of interfacing, or electronically connecting such peripherals, is also a function of the design of microcomputer hardware. In many cases, more expensive technology offers more potential for expansion. The open architecture of some microcomputers — notably Apple and IBM computers — with six or more slots in their printed circuit boards, allows independent developers or vendors to devise custom circuit boards to plug in many of these applications. Less expensive computers — for example, many Commodore and Radio Shack computers — have a limited number of standard input and output ports on them, but unlike those with open architecture, they do not easily support multiple peripheral devices.

SOFTWARE: HARNESSING ELECTRONICS TO FOLLOW HUMAN INSTRUCTIONS

Software is the set of instructions that makes computers perform their various tasks. Computer programming languages, operating systems, games, word processors, database programs, databases, instructional programs, and spreadsheet programs are all examples of computer software. (Newcomers to the world of computer technology are often astounded that hardware engineers — the people inventing and building computers — frequently know little about software, and that software creators often have little idea about how the circuits make sense of their commands. It helps to make the analogy with television: how many writers, directors, and producers know how to repair their own sets?)

Although attempts to create effective computer software for mainframe computers have been going on for almost two and a half decades, the art of writing microcomputer-based software for instructional purposes is less than 10 years old. Nevertheless, there are now thousands of software programs available for the K-12 software market.* Electronic Learning magazine counted 1,145 new software programs between March 1985 and March 1986, an average of almost 100 programs per month.[15]

Software can be delivered via a number of media; the most commonly used are floppy diskettes, magnetic media about the size of 45 rpm records, wrapped in paper envelopes. Programs can also be delivered on cassette tapes or even printed out on paper and then typed into the computer manually. ! They can be sent and received over telephone lines with the proper equipment and protocols. Although various special “copy protect" routines have been tried, there are very few software protection schemes that can keep programs from being illegally copied. And when software is copied, the copy is identical to the original. It suffers no loss of quality.

It is important to realize that software written for one type of microcomputer operating system will not in most cases run on another. Software developed for Apple IIe, for instance, will not run on Commodore, Tandy, or I.B.M. microcomputers. Software publishers who wish to make their programs available for every system have to adapt them for use on those systems, which usually means rewriting them entirely, which can add significantly to development costs. For this reason, the decision to buy a certain Type of hardware is often based on what software will run on it.

Educational software falls into the following general categories:

1. Operating Systems
2. Languages
3. Utilities (word processors, spread sheets, database management, desk-top publishing)

---

* There is a great range of educational software both in quality and price with the median price at about $50 per copy. The market for educational software is relatively small compared to that for business. It is possible that, in the future, severe problems in availability of high quality software can arise from the apparent fact that publishers have difficulty making much profit from educational software production. Writing an effective software program can cost up to $500,000 and as much as $1 to $1.5 million for a year-long curriculum. The educational market seems unable to bear a significant markup on this type of product.

15. Electronic Learning, "Micro Waves – Editor’s Note/’ vol. 5, No. 8, May/June 1986, p.2.

4. Instructional Programs (computer-aided instruction, drill and practice exercises, computer managed-instruction)
5. Simulations and Games
6. Communications

Operating Systems Software

Operating systems software controls the internal workings of a computer; for example, its communication with diskette drives, keyboard, and screen. Operating system software also coordinates the actions of the multiple computers in a distributed network of computers.

Operating systems continue to evolve as new hardware and applications are developed. The need for them to communicate with non-expert computer users has prompted development of simpler operating system instructions. To obtain a listing of the contents of a diskette, for instance, it might be necessary to type "DIR" (directory) for one system and "LOAD $,8” then "LIST" for another. Yet another requires "CATALOG" and another "CAT." One solution, used in the Apple Macintosh, has been to create graphic icons to represent various functions; for example, a trash can to represent the delete function.[16] Although such icon-based systems have had much success in ‘he consumer market, the impact of computer operating systems on educational applications has yet to be effectively assessed.

Computer Programming Languages

In 1965, John G. Kemeny and Thomas E. Kurtz of Dartmouth College developed the BASIC programming language for introductory courses in computer science. Somewhat similar to FORTRAN, the most widely used scientific programming language, BASIC has

16. Peter J. Denning and Robert L. Brown, ‘Operating Systems,” Scientific American, vol. 251, No. 3, September 1984, p. 72.

fallen out of favor at post-secondary levels, but remains the most popular programming for microcomputers.[17] Many are made with BASIC "hard wired" —a permanent part of their architecture.

In elementary and secondary schools, learning how to program in BASIC is a regular part of many programming courses, and is included in many computer literacy programs. Children learn to print out their names on the screen multiple times using a numbered BASIC command list such as:

```
1 FORX=1TO1OO
2 Print~Maryn
3 NEXTX
```

Such a program can teach the child about the computer's ability to use variables and to repeat instructions to accomplish tasks.

Teachers can also use BASIC to create their own simple programs for record keeping or instruction. However, this appears not to happen very frequently. Creating useful programs is very time consuming, and lengthy BASIC programs typically operate very slowly, causing frustration for those who expect video game-like speed. For this reason, and to make programs more reliable, most commercial programs are written in more sophisticated programming languages or in machine language, both of which require more expertise and technical skill.

Another popular computer programming language was designed expressly for children. LOGO, developed with support from the National Science Foundation (NSF) by Seymour Papert and his colleagues at the Massachusetts Institute of Technology, is a language built around the concept of making a simulated "turtle" robot trace shapes on a

---

17. Lawrence G. Tesler, "Programming Languages," Scientific American, vol. 251, No. 3, September 1984, p. 72.

computer screen according to the child% program of instructions, such as "FORWARD 50" and "RIGHT 145". These instructions can be embedded in routines, recalled any number of times, or put into conditional statements. Logo is used in many schools to teach programming concepts and problem solving.[18]

Because BASIC comes built into the most popular microcomputers and LOGO is high on the list of "most used programs" reported by educators,[19] these are probably 'he principal computer programming languages used in schools. Other computer programming languages used in science, business, and universities, such as Pascal, COBOL, FORTRAN, Forth, APL, Prolog, Algol-58, and Lisp, each having its own rules, syntax, conventions, and special area of application, are only occasionally taught in higher grades and/or specialized courses of instruction about programming.

Utilities

Utilities or applications programs allow students to use computers as tools to accomplish certain tasks like typing or processing words, making spreadsheets, maintaining databases, creating computer-aided designs, making music or visual images and graphics.

They generally present no instructional information except menus of their capabilities or help lists. Some incorporate a number of different programs. APPLEWORKS for instance, the most popular utility program, integrates a word processor with a spreadsheet program and a database manager. Such utilities are similar to programs that students will most likely meet in their working lives, in offices, factories, or businesses, where utilities like LOTUS 123 account for millions of dollars of sales every year.[20]

---

18. Margie Plock, "Computers in Schools: Can They Make the Grade?" High Technology, vol. 6, No. 9, September 1986, p. 48.
19. TALMIS Inc., The K-12 Market for Microcomputer & Software (New York: 1986), Table 30.
20. Victor E. Fuchs, "Computers and Public Education: At the Crossroads of

Some districts report that utilities are being used more than any other kind of software. A recent Talmis survey of school computer coordinators found that 9 of 10 most used programs were utilities. (See Table 2)

Using a word processor program can give children confidence in writing, as it does with many adults, and separates the effort of composition from the physical dexterity problems of handwriting; using spreadsheets and data base programs can aid students in compiling and analyzing data for science projects. In recognition of the growing use of these utilities in classrooms, software publishers have begun to expand them to include helpful hints and organizational structures for young writers, for instance, to guide them through the pre-writing and planning stages of composition. Some publishers have added curriculum databases to their database management utilities, so they can be used by students to do research. Subjects like U.S. history, government, life sciences, physical sciences, literature, composition, poetry, mythology, world geography, and cultures are now available.[21]

New tools have also been developed to help in analyzing science projects. For example, Robert Tinker and collagues at Technical Education Research Center (TERC) in Cambridge, Massachusetts, have developed several sets of low-cost peripherals and software that enable children to use computers to take data from hands-on experiments and display the data graphically in real time. These microcomputer-based laboratory programs deal with heat and temperature, velocity and acceleration.

Instructional Programs (computer-aided instruction, drill and practice exercises, computer managed instruction)

This category of software is made up of computer programs specifically designed to instruct or to provide drill and practice. Occasionally they also incorporate some testing

---

Educational Excellence," Electronic Learning, vol. 4, No.8, May/June 1985, p. 34.
21. Plock, op. cit., p. 48.

Table 2

SOFTWARE TITLES USED MOST FREQUENTLY

Title	Percent of Respondents
Apple Works (Apple)	19
Print Shop (Broderbund)	18
Bank Street Writer (Broderbund/Scholastic)	16
Logo	14
PFS: Write (Software Publishing/Scholastic)	8
Newsroom (Springboard)	7
Magic Slate (Sunburst)	6
Master Type (Scarborough)	5
PFS: File (Software Publishing/Scholastic	4
Math Sequences (Milliken)	3
Microzine (Scholastic)	3

N=119

Source: Talmis, Inc. New York, personal communications, October 1986.

procedures and keep records of progress. When testing is used as part of a program to determine when a student is ready for anew level of instruction, and records of progress are kept, the method is called “computer-managed-instruction."

There are instructional programs to teach almost every subject of the school curriculum — mathematics, language arts, social studies, early education, science, foreign languages, typing, and business education. Some programs are simply “electronic page turners" and present the learner with screen after screen of text with no interaction from the user but to press a key for the next page. Others present simple mathematical problems, giving little help to the learner except to disallow false answers. However, other programs designed for drill and practice exercises are written with added embellishments to provide motivation and variety. For example, QUOTIENT QUEST from Minnesota Educational Computing Consortium (MECC) incorporates an around-the-world theme. Successful completion of division drills allows students to search for chimpanzees, rearrange totem poles, trap a jewel thief, and perform other challenging tasks.

Drill and practice software can be seen to offer certain benefits to the learner. Due to the fact that the computer provides instant feedback, unlike having a worksheet marked and returned the next day, the student learns to find the correct answer immediately. In the words of Mark Grabe, Associate Professor of Psychology at the University of North Dakota in Grand Forks,

> I believe students need to have access to their thoughts, decision criteria, and recollection of other mental activities in order to make the most of feedback. This feedback must be given within moments of the student% original response for full access to these recollections. In a practical sense, I believe the studentts likelihood of being able to operate in this time frame will be greater when engaged in computerized drill and practice.[28]

As hardware has become more sophisticated and as the market has grown, incorporating more colored graphics and sound into programs has added greatly to their

22. Mark Grabe, "Drill and Practice% Bad Rap," Electronic Learning, vol. 5, No. 5, February 1986, p. 22.

attractiveness. Some now provide scenarios or game-like settings for these exercises, such as a shopping mall setting for mathematics practice, where students work against time to serve customers in various shops.[23]

John Henry Martin notes:[24]

> Clearly, the natural appeal of games should not be ignored; integrating game theory with the content and skills to be taught has a synergistic effect. Chance and risk, along with graphic evidence of growing skill perceived by the participant, are strong reinforcers. Challenge and humor can be effective lubricants to learning. Nevertheless, covering the stale bread of dull materials with a confection of gaming has not made an educational cake.

Notwithstanding some very innovative and excellent software written for limited systems, the problems of writing new educational software for computers with limited memory and rudimentary graphics capability is substantial. Due to these machines' limited speed, learners can easily get frustrated with programs that do not respond immediately and begin pushing keys at random. For programs that do not have special lockout devices, this can precipitate even more problems and possibly even cause programs to "crash."[N] This encourages program writers to restrict the graphical content of programs because graphics tend to consume much processor time and memory. And the amount of internal memory an 8-bit microprocessor is able to access (64,000 bytes) also limits its ability to offer options to the learner. According to one developer, 'Trying to fit a complex education program into a microcomputer with 64 kilobytes of memory is like trying to park a limousine in a tiny garage without scratching the paint."[25]

Nevertheless, software developers, presently substituting ingenuity for computing power, are hopeful that schools will soon be encouraged by the increased capabilities of new hardware, and the software it can support, to acquire micros with faster speeds,

---

23. Larry Pogue, "Math Goes to the Mall," Electronic Learning, vol. 5, No. 8, May/June 1986, p. 55.
24. John Henry Martin, 'Developing More Powerful Education Software," Educational Leadership, vol.43, No.6, March 1986, p. 33.
25. See comments by Virginia Gemmell, Director of Research and Design for Spinnaker Software in an article by Plock, op. cit., pp. 44-45.

more memory, and better graphics capability. One new trend in software development that has followed the introduction of more powerful hardware is the effort to incorporate "intelligent feedback" into instructional programs. TYPING TUTOR III records a user's response time for each key and uses this information to modify subsequent lessons, automatically providing more drill for the user's weakest areas.[26]

Work is now underway at a number of universities and laboratories to improve computer aided instruction by the application of cognitive science and artificial intelligence. One such program at Carnegie-Mellon University, Pittsburgh, uses a mainframe computer (Xerox 1109 Advanced Scientific Information Processor) to help students learn geometry. The designers of the geometry tutor describe its special features:[27]

> At any time in the process, the student can ask the system for help with definitions, postulates, and theorems appropriate to the problem. In addition, if the student is not *on* a proof path, the tutoring part of the system (that is, that part that keeps track of the student% strategic choices) will guide the student back onto a path. Should the student make a logical error in inference, the system recognizes the error and tutors accordingly. The system functions as coach or as tutor, depending on need.

With these features Carnegie-Mellon University researchers believe that in the near future, a mathematics laboratory could become a standard high school facility. These highly sophisticated interactive environments or so-called intelligent computer-assisted tutors could enable students to work productively on their own time at school or at home.

---

26. Ariella J. Lehrer, University of California, Los Angeles "Some Hard Words on Software Policy,ff unpublished typescript, July 1984.
27. C. Franklin Boyle, "The Geometry Tutoring Project in Action,'f Educational Leadership, vol. 43, No. 6, March 1986, p. 27.

Simulations and Games

Simulations are programs that generate practice environments in which learners can experiment. They simulate processes, systems, or events. One very popular simulation from MECC is of a wagon train on the OREGON TRAIL. Students of history make decisions about what provisions they will need, what time of year to start their journey from St. Louis, and in what activities to engage, e.g., whether to hunt or trade. Random events like attacks by Indians are also programmed into this simulation for added realism.

Another program called THE MARKET PLACE is an economic simulation for younger students in which the students operate, amongst other things, an imaginary lemonade stand. Typically, a teacher will divide a class into groups, each deciding how much of a limited amount of money they will spend on lemonade, on a sign for advertising, and other variables. The computer will then simulate transactions based on the outcomes of their decisions. Some groups will make a profit and others might find they have gone broke, not having spent enough money making their service known.

There are political simulations of presidential elections, economic simulations of factories, physical simulations of weather systems, automobile simulators, airplane simulators, and space flight simulators. Other simulations allow students to conduct science experiments, such as dissecting a frog or making chemical compounds. Such simulations have many benefits. They can simulate processes that are dangerous, time consuming, or costly, and allow students to repeat them, stop them, or alter variables to find out what happens. In the case of the dissection program, the student is also required to reconstruct the frog, and thus reinforce the learning experience.

Many computer games are also simulations, although often they simulate unreal environments. Games have been used by teachers to encourage students to write, to improve hand-eye coordination, and as a reward.[28]

Researchers and software developers have used the format of games to understand the learning process and to create innovative instructional software. The game DARTS, for example, was developed by Sharon Dugdale as part of an NSF-sponsored research project using the PLATO IV computer-based education system. To give elementary students practice with estimating fractions, balloons appear at random places on a number line on the screen and players try to guess the positions of the balloons. After students enter their guess (whole numbers and/or fractions), an arrow shoots across the screen to the position specified.

Dugdale also produced another game, GREEN GLOBS, to assist student in understanding the meaning and uses of graphs. The student writes an equation so that a curve will be generated through a series of "globs" placed on a graph by the computer program, and make them explode. "Students 'win' by developing a good sense of how to generate curves with particular properties by typing in their equations; thus the students who get good at the game learn the relationship between the algebraic and graphical representations of a function."[29] Another type of simulation, called construction sets," has been the subject of recent development. These programs reflect the idea that, given certain tools, simulated computer environments can be created by the learner, and can encourage a learner to explore a concept or set of concepts. Music construction sets and pinball construction sets, where the player constructs and then plays a simulation, have become commercially successful software programs. The same principles have been used to design geometry and physics programs.

28. Esteben Diaz, Laboratory of Comparative Human Cognition, University of California, San Diego, CA, address to2020 panel, Oct. 16, 1986.
29. Alan H. Schoenfeld, 'Mathematics, Technology, and Higher Order Thinking Skills in the Near and Not-So-Near Future/' presentation to 2020 panel, Oct. 16, 1986.

Communications ‘

With the application of a modem, an instrument that connects a computer to a telephone line, and the appropriate software, a microcomputer can be used to communicate with other computers and thus allow the user to leave messages for other users in the form of electronic mail, to access data from data libraries, or to “download” software from software libraries. Such computer communications can expand the resources of a classroom to include information from worldwide sources. An estimated 40 percent of high schools, 18 percent of junior high schools, and 10 percent of elementary schools have at least two modems.[30]

Hundreds of commercial databases are available for professional and non-professional use. One example is NEXIS, which contains the fully indexed contents of news stories from the New York TIMES and many other newspapers and periodicals; this service can cost over $100 per hour of access time. CompuServe and The Source, which have been set up for a broader consumer market, and which contain educational bulletin boards for educators and students, cost approximately $25 per hour of connect time during business hours, and less than $10 in the evening and on weekends.[31]

Available online resources range from nationally-run information libraries, available through telephone networks designed for computer communications, such as Telenet, Tymnet, and Uninet, to local bulletin board systems that may be set up by amateur system operators using microcomputers. A very wide variety of services can be found on the national systems; news wires, business information, weather, sports, employment services, tax information, computer conferencing, personal mail services, travel, shopping, movie reviews, games, and others. The private bulletin boards tend to specialize in computer information, software (both public domain and pirated), and informal conversation.[32]

30. TALMIS Inc., New York, personal communications, October 1986.
31. Loy A. Singleton, Telecommunications in the Information Age, second cd., (Cambridge, Mass: Ballinger Publishing Co., 1986), p. 171.

Often used in school libraries, news and information services such as Dow Jones News/Retrieval can be valuable as a reference for world history, literature, and project research. Some schools display world news throughout the day on video monitors in the hallways to keep students aware of world events.[33] Online databases can be a valuable resource, especially where libraries are limited by funds, or where students have limited access to resources because of locale or physical disability.

Also of interest to educators are various software evaluation databases such as EPIE Online, and related computer conferences or forums, where teachers can communicate with hundreds of other teachers, and share experiences, information, and even public domain computer programs.[34] And there are a number of special bulletin board systems, operated by some State education agencies, local school districts, universities, high schools, and computer societies, dedicated to education and educational matters, that welcome teachers and students alike.

Several colleges have already begun delivering instruction using online computer conferencing systems. An organization affiliated with the New School for Social Research in New York has offered eight graduate and two undergraduate courses entirely via computer conferencing to students in California, Nevada, Chicago, Wisconsin, Delaware, Rhode Island, New Jersey, and New York, as well as Singapore, Japan, and the Middle East. A few elementary and secondary schools have begun to use computer conferencing on an experimental basis. It is expected that a number of classrooms will join the Kidnet Project that has been designed by the Technical Education Research Center in collaboration with the National Geographic Society. With funding from the

---

32. Mike Cane, The Computer Phone Book Directory of Online Systems (New York: New American Library, 1986)

33. Harold J. Logan, Dow Jones and Co., Inc., personal communication, December 1986.

34. For example, an online database of over 20,000 children’s radio and television programs has recently become available. Called "KIDNET," it includes information on air dates, content, target age, grade level, curriculum area, educational goals, ancillary materials, and copyright requirements. See Classroom Computer Learning, ‘Industry News/’ vol.?, No. 4, January 1987, p.60.

National Science Foundation, Kidnet will involve children across the country in conducting scientific measurements around a unit of study such as environmental pollution. Using computer communications, these measurements will be analyzed with the aid of online science experts. Classrooms will communicate with each other and receive ongoing local and national results.

Communicating by computer seems to provide some students with a special kind of motivation. For example, California students in bilingual and remedial classes become computer "experts" and use computer communications as a way to build literacy and language skills. According to the director of this innovative project:[35]

> The [computer] network virtually allows the world to become a community resource for students in the barrio and ghetto. Students are able to "leapfrog" societal and economic barriers and create a resource network that encompasses the next neighborhood or another country. In this case, the resources provided by the network are opportunities to practice and develop literacy skills in order to communicate with their electronic friends. Friends in Spain, Harlem, or another part of San Diego are all electronically equidistant. Moreover, this means of communication operates from a presumption of equality and mutual respect that is hard to attain in face to face interactions. For students who speak another language, communication with countries in their native language reaffirms their personal heritage and underscores the value of being bilingual and illiterate. Students who participate in settings where access to electronic networks is part of their everyday routine develop different perspectives about themselves and the world. Communication leads to appreciation and understanding of others which then leads to collaboration and cooperation in joint activities of mutual interest.

Using computers for communicating represents a very small proportion of computer use in schools. Perhaps because of the difficulty of getting a telephone connection into the classroom, or because online costs are use related and difficult to project, or because administrators fear abuse or fail to see any academic benefit, instances of computer communications by students in class are extremely infrequent.[36]

---

35. Esteben Diaz, ‘Educational Change and Educational Technology,"unpublished presentation to Technology in Education in 2020 panel, Oct. 17, 1986.
36. Hugh F. Cline, et al., The Electronic Schoolhouse: The IBM Secondary School Computer Education Program (Hillsdale, N.J.: Lawrence Erlbaum Associates (1986,) p. 66.

Video: The Eyes and Ears of the Electronic Revolution

Video technologies can bring the outside world into the classroom in a way that the limited visual screens of computers or unwieldy film technology cannot. Videocassette recorders have rapidly diminished in price and in size and increased in availability to the point where almost 40 percent of all television households own them. School use has also vastly increased in the last 3 years, with a total penetration in 1984 of 50 percent, in 1985 of 75 percent, and in 1986 of almost 90 percent of public schools owning videocassette machines.[37] In addition, at least 70 percent of all U.S. schools can receive broadcast instructional television programs from Public Television stations, and, according to a study conducted by the National Center for Educational Statistics, Instructional Television (ITV) school utilization averages 20 minutes per school day, or about 5 percent of available class time.[38]

Clearly, teachers believe that video is an effective adjunct to class instruction. TALMIS reports that the preferences of program purchasers were for instructional tapes and discs in basic skill areas, followed by short-subject demonstrations, simulations, and historical recreations. More than half would like to see more documentaries.[39] Nevertheless there is a large and growing body of pre-recorded instructional and informational video programs available from an increasing number of sources. Of particular note is The Video Encyclopedia of the 20th Century, published by CEL Inc., 75 l-hour videocassette tapes of the social, political, and cultural history of the 20th century. The encyclopedia includes a master index, a ‘reference set', four volumes of background material on each of the 2,217 separate units, including detailed "shot lists" of the important people and places in each scene, and a curriculum guide to aid teachers in incorporating the material in various courses of study.

---

37. ‘Microcomputer and VCR Usage in Schools: 1985-1986," edited by Jeanne Hayes, Quality Education Data, Inc., Denver, CO (1986).
38. National Center for Educational Statistics, 1982-83 School Utilization Study (Washington, D. C.: Corporation for Public Broadcasting, 1985).
39. Anne Wujcik, TALMIS Inc., New York, personal communication, October 1986.

This use of videotape represents a relatively new attitude towards video materials and a response to the individual teacher% increasing access to video playback technology. This has also prompted the largest program provider, the ITV organizations of the Public Broadcasting System (PBS), to respond with new services and distribution methodologies. Now, rather than requiring teachers to schedule class viewing time to suit the schedule of the local PBS station, a number of such stations have set up experimental video library systems, where programs are broadcast in a block schedule either in the early morning hours, or overnight, for the school to record on videocassette. A school building can then store and retrieve instructional television programming and make it available to meet the teachers' day to day curriculum needs: Moreover, this experiment has been carried out on a nationwide basis by WNET using PBS satellite ‘downtime’ overnight, making the service more cost effective.[40]

Currently, distribution of ITV programs to schools takes many forms. Programs on tape can be bought, leased, or rented directly by schools. Programs can rerecorded off-air at the time of broadcast and licensed through an agency of the broadcaster. Multipoint narrowcasting, or ITFS (Instructional Television Fixed Service) allows teachers to order programs from a central licensed facility. And virtually all Public Television stations feed their broadcast signals into numerous CATV (cable) systems. Some stations also feed special user locales over coaxial and fibre-optical cables. However, limited use of satellite dishes at school sites – Direct Broadcast from Satellite (DBS)–has been the subject of much study and experimentation among PBS system participants. As of summer 1986, 510 school districts reported having satellite dishes.[41] However, in 1986, the Kentucky legislature funded a new educational television channel and satellite receiving dishes for every school building and public library in the State opening the way

---

40. ITV Futures Planning Group, "Learning Technology Issues for the Future," unpublished typescript, Aug. 7, 1985.
41. Quality Educational Data phone survey, “Does your school district have a satellite dish?" as reported in a letter from P,B.S. Director of Elementary/Secondary School Services to OTA, Dec. 17, 1986. (Additional data to come from QED).

for much more direct from satellite programming than ever before. It should be noted that once Kentucky puts its educational material up on the satellite, that material will be available to any dish pointed at that satellite from anywhere in the continental United States. It is possible that other States or individual schools might want to purchase viewing and/or taping rights for their programs.

Teleconferencing, with live, two-way video communication has also been the subject of limited experimentation. Of special note is the East Central Minnesota Educational Cable Cooperative project to link seven rural districts with two-way interactive television, with each classroom able to see the teacher and the other online classrooms. A master teacher can now teach up to four classes in four districts at a time in subjects that were previously unavailable to them.[42]

Nevertheless, the overwhelming use of video technology in public schools is for playing prerecorded cassettes and off-air recording. And even though many useful purposes can be served by employing a video camera along with video recording equipment, such as critical viewing skills, media literacy, taping and archiving school events, recording data from science experiments, and self-analysis in sports activities, very few schools taking advantage of this hardware.

However, this may be changing. Recently developed camcorders, with videotape recorders included in the camera, many of which have solid state pickup devices instead of fragile imaging tubes, and which are becoming less expensive, may have an impact on this type of use. A survey conducted recently by the New York State Education Department shows a dramatic increase of video-related applications, with 5,000 teachers using such technologies to produce video programs with students in their classrooms.[43]

One such program, called the Poetry Video Learning Project, operates in four New York City schools and involves chronic truancy students with practicing poets in making

---

42. School Tech News, '2-Way TV Enriches Curricula in 7 Districts/' September 1985.
43. Mary Lee Shalvoy, et al., 'State Briefs: New York," Electronic Learning, vol. 6, No. 2, October 1986, p. 16.

"poetry videos," similar to music videos. Students write a script, perform, and act as production personnel during taping. As one part of the Dropout Prevention Program, it has increased attendance 15 percent, according to school officials.[44]

Another video technology which may have real potential for instruction is videodisc technology. Videodiscs offer many advantages over videotape players with the exception of the ability to record. A teacher can easily pause the videodisc player on a still frame, slow motion forwards or backwards, and have almost immediate access by frame number to the entire half hour of material on each side of the disc. In addition, the visual and audio quality of videodisc images is vastly better than VHS videotape. Some videodiscs contain thousands of individual frames that can be displayed one at a time and in any order, much like a slide projector with up to 54,000 slides.

New Delivery Systems and Convergence of Technology for School Use

As instructional technologies continue to evolve, many new and powerful systems are being created by the convergence of computer technology with communication technology, especially television and the telephone.

An interactive videodisc system uses a videodisc machine as a peripheral to a computer. The resulting system permits the interactivity usually associated with computers to be enhanced by visual images with the resolution and dynamism of video. According to the responses of the learner, audio-visual sequences can be played multiple times, slowed down, or overlayed with computer graphics, perhaps to enhance an explanation or point out details. Such systems can involve the learner in powerfully realistic simulations, or give intelligent access to libraries of visual images and data never before possible.

The Voyage of the Mimi, a multimedia project in science and mathematics developed by Bank Street College of Education, is a television series plus a computer

44. New York Times, "Poetry-Video as Tool Keeps Truants in School," Jan. 11, 1987.

based science laboratory plus an interactive videodisc. Students watch a 15 minute fictional episode followed by a 15 minute documentary expedition about a scientific principle crucial to the drama. They can then work with the print materials that " accompany the package, and next experiment with provided lab tools; temperature, sound and pressure instruments connected to their computers. With these they can make measurements over time and have them displayed as dynamic graphs on the computer screen. Such activities can then be followed by an interactive videodisc-based exploration of the scene where the drama took place.

Another example of technologies combining to provide educational opportunities is a system that uses audio-graphic teleconferencing. With the aid of a microcomputer, light pen or graphics tablet, modem, and conference telephone, Garfield County, Utah, school officials offer a calculus class in four high schools, though the district may employ only one calculus teacher. Such a system allows a centrally located teacher to speak with all the classroom participants at once through speakerphones. In addition, the teacher can draw or plot on a common video screen. During discussion, any student at any site can also draw on the screen and the rest will observe the change. Prerecorded images can be called up from any participant's computer, and any image can be saved on any participant% computer for further reference.[46] Similar distance learning projects are also underway serving remote communities in central New York State.[47]

Distance learning, or remote learning systems are the subject of much experimentation in at least four States. The need to provide expert teachers in remote rural communities, where there are few qualified teachers for certain subjects, has caused the establishment of some very innovative programs involving such a mix of technologies.

---

46. Todd **Stubbs,** 'Long-Distance Chalkboard,^{w} Electronic Learning, vol. 5, No. 1, September 1985, p. 14.
47. Jane **Perlez,** 'Long-Distance Teaching,^{M} New York Times, vol. 135, No. 46,626, Dec. 17, 1985, p. **C1 & C19.**

In Oklahoma, the number of high school students taking German doubled in one year after Oklahoma State University began offering a televised language class to 50 schools in Oklahoma. And students at 26 schools in Utah, Nevada, Colorado, and Arkansas began taking a' satellite Spanish course broadcast from Utah. The difference in these classes is that the teacher broadcasts over the satellite "live" and is also connected to each classroom by telephone. So the students can ask questions, practice speaking the language they are learning and interact with the instructor just as if he or she was in the room with them.[48]

In the Oklahoma experiment, students' homework assignments are sent over modems to the remote instructor for marking. The integration of technologies enhances the learning experience and, because of it, these students are able to take courses completely unavailable otherwise.

The distribution of computer information, programs, and data to remote locations that would otherwise need to spend large amounts of money on long distance telephony to access programs or services in city centers, is also a problem. One experimental program being run by the Center for Mathematics, Science and Environmental Education at Western Kentucky University uses the Early Warning System to broadcast courseware to rural schools. Using a mainframe computer located at the university, 21 schools in 14 districts are tied into the program using microwave relay stations operated by the Early Warning System which are relayed to local telephone lines, saving hours of long distance telephone charges.[49]

Experiments with broadcasting software to schools across the Nation are also being carried out by the Software Communications Service, an organization of 17 State Public Broadcasting systems and five Canadian provinces who are developing broadcast

48. Francis C. Brown, III, "Televised Classes Help Rural High Schools Offer Fuller, More Demanding Curricula," The Wall Street Journal, Nov. 12, 1985, p. 31.
49. Electronic Learning, "Kentucky's CAI Capability," vol. 5, No. 5, February 1986, p. 10.

television's ability to carry computer information, at the same time as pictures and ' sound, to distribute instructional software to thousands of classrooms at a fraction of the cost of conventional distribution.[50]

Another area where technologies are converging, and must be considered by educators for the future, is robotics. When a computer is connected to an electromechanical device it becomes a robot. The population of robots in industry is growing steadily, with new applications in many fields arising in many unexpected industries, from candy makers and pharmaceutical houses to underwear manufacturers and plastics molders.[51] And there are some robots especially made for educational purposes. What success they can have in educational settings is yet to be discovered when more are used in classrooms. However, John Primozich, an Ysleta, Texas, primary school instructor believes that robots are perhaps the most efficient — as well as the most fun way for kids to gain experience with technology. The Ysleta schools have 10 friendly robots costing approximately $2,500 each. As they are capable of being programmed, he says, they encourage students to learn programming as well as increase their awareness of the technology around them.[52]

---

50. Software Communications Service, "New Nationwide Software Communications Service Formed by Educational and Telecommunication Groups," press release, October 1, 1986.
51. Russell Mitchell, et al., "Boldly Going Where No Robot Has Gone Before, " Business Week, Dec. 22, 1986, p. 45.
52. National School Boards Association, "Robots Make Computer Literacy Fun," New Technologies: Key To More Productive Schools, N. S.B.A. Leadership Report, vol. 1, . 1985, p. 26.