CHAPTER 1

COMPUTERS IN AMERICAN EDUCATION: TRENDS AND STATUS

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> 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.

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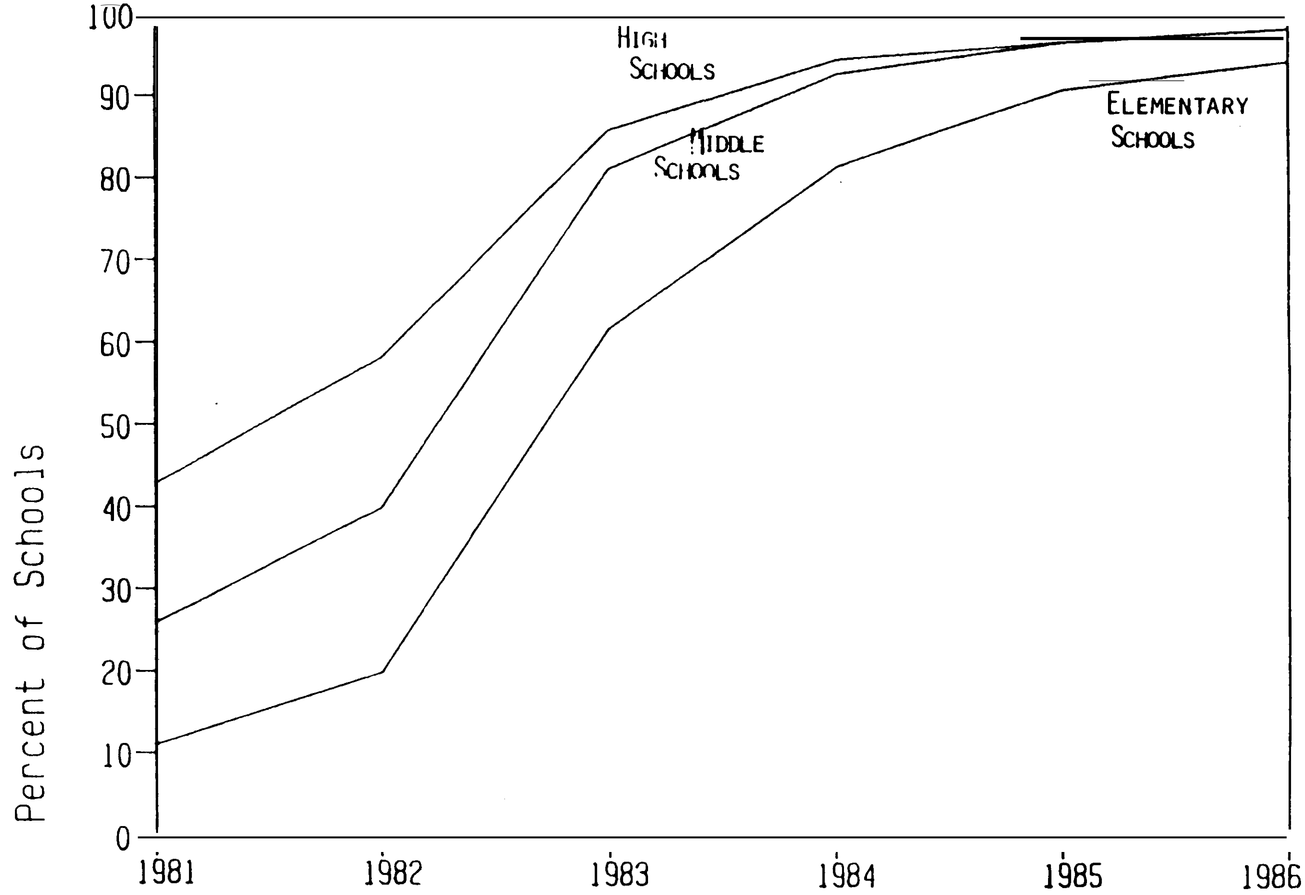
* This chapter provides a statistical overview of changes in the utilization of computers by U.S. elementary and secondary schools from 1981 to the present. It serves as the context for more detailed discussions of how technology is used in Chapter 1 programs and in programs for children with limited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

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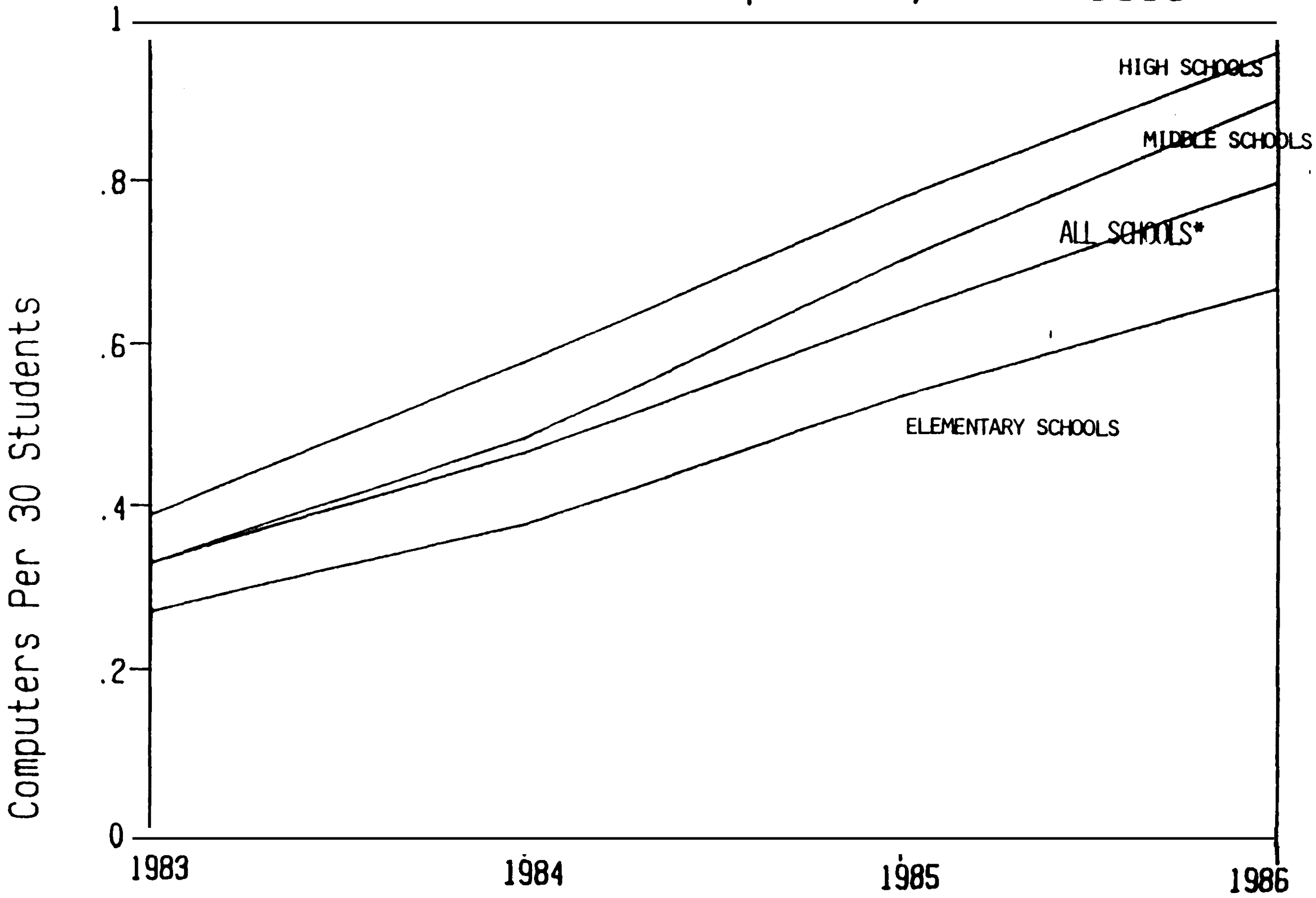
* This measure was suggested by Becker, who also experimented with a variety of access measures with differing statistical properties.

** 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

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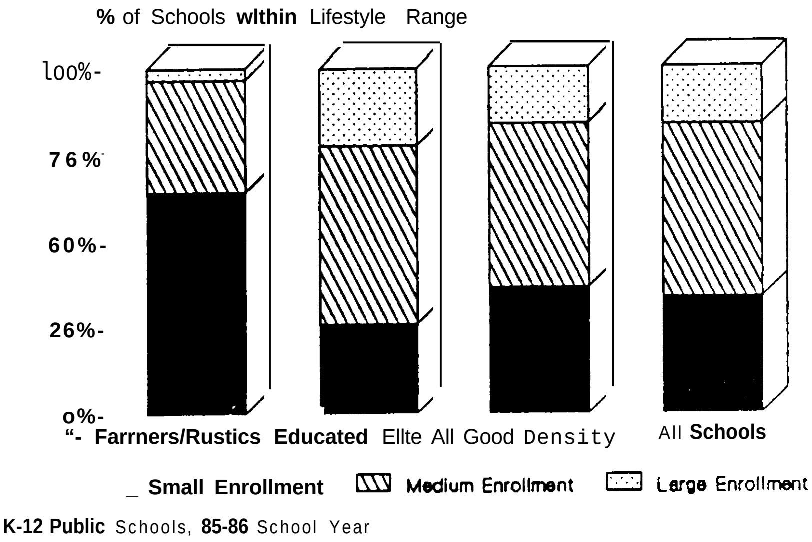
** Based on a procedure developed by Claritas, a Washington-based demographics research firm. See notes on methodology and data, part c at the end of this chapter.

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.

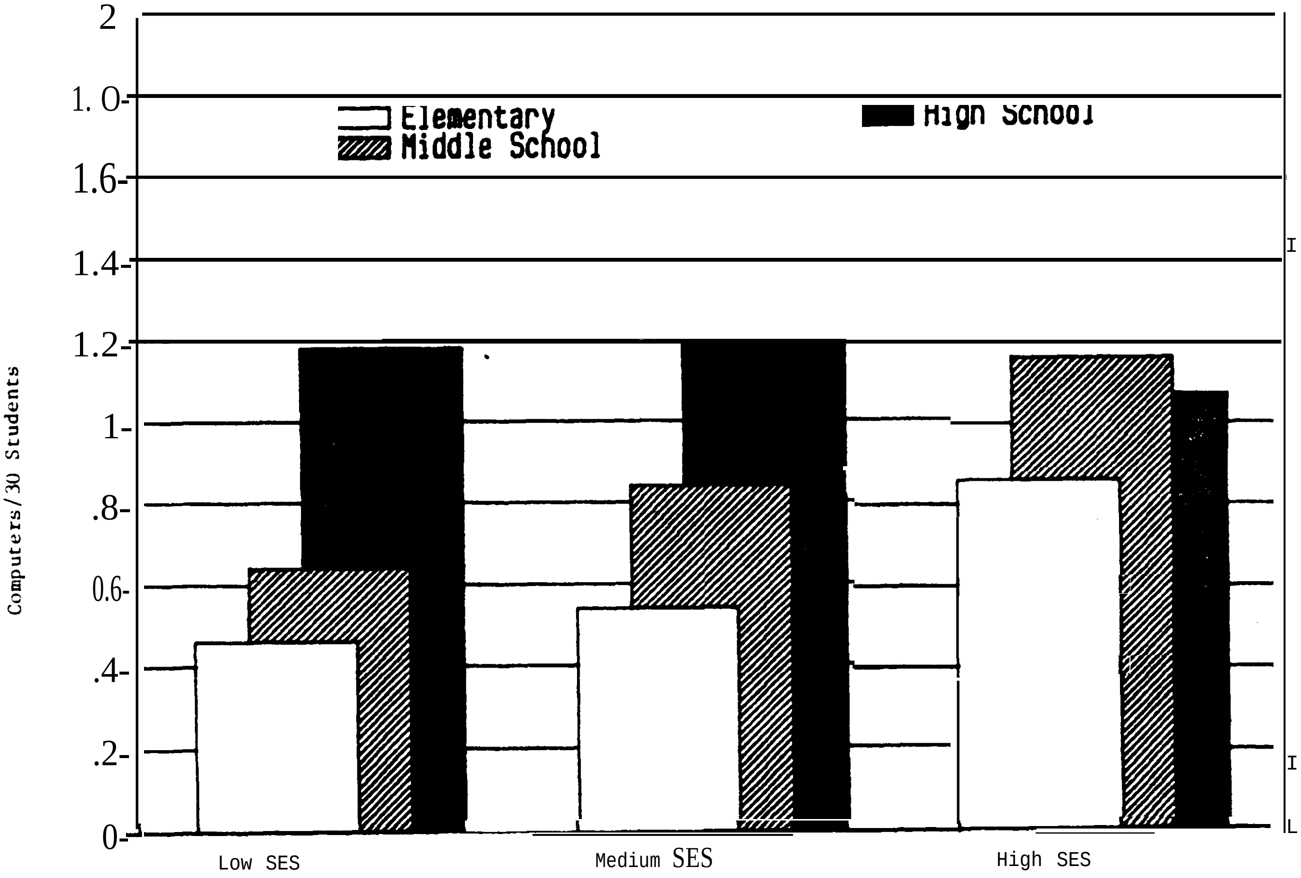
equipment as rapidly as rich ones, but that there are now few schools — rich or poor — with no computers.

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)

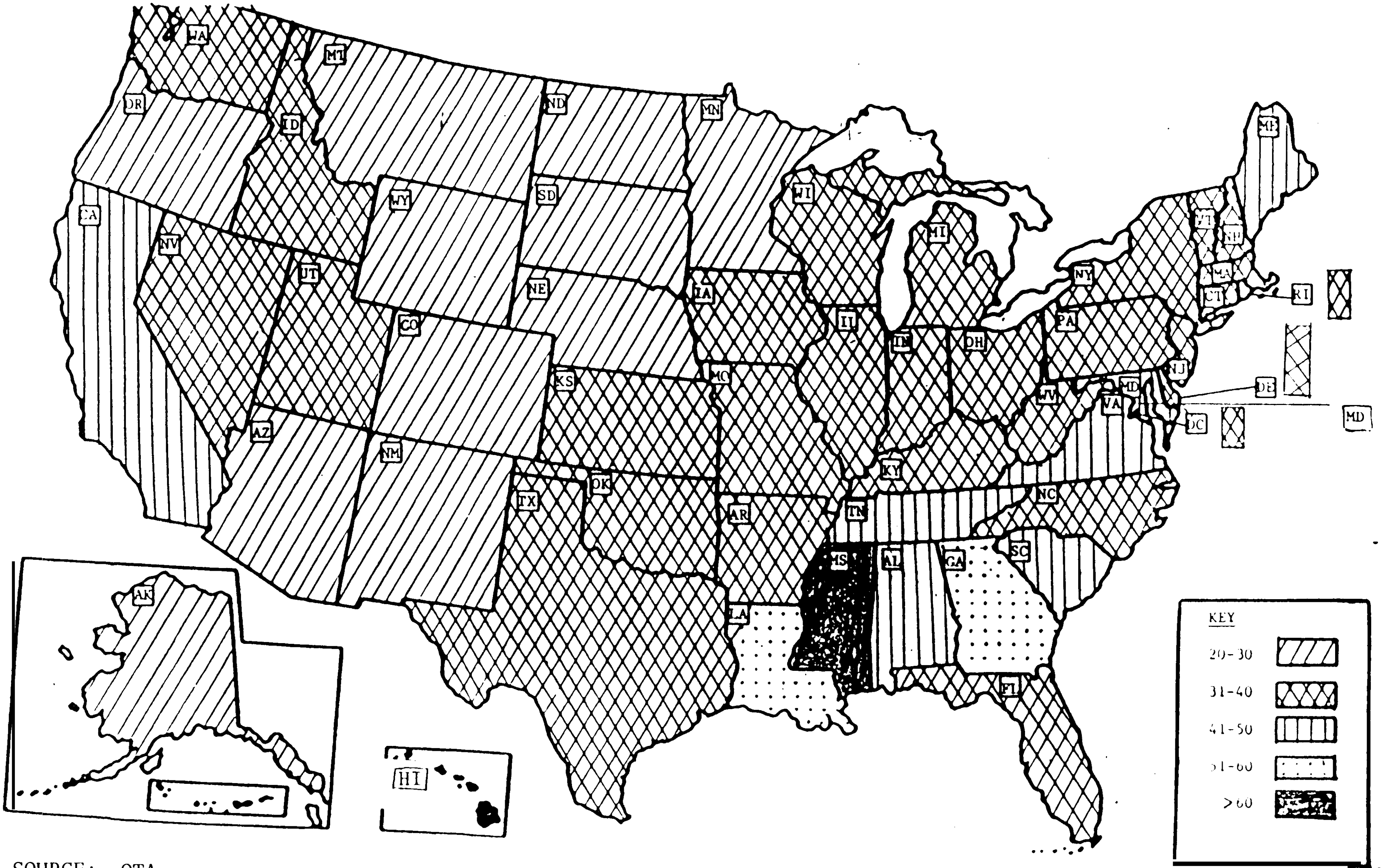


*SES measure based on school-wide index of parents' occupations and incomes

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.

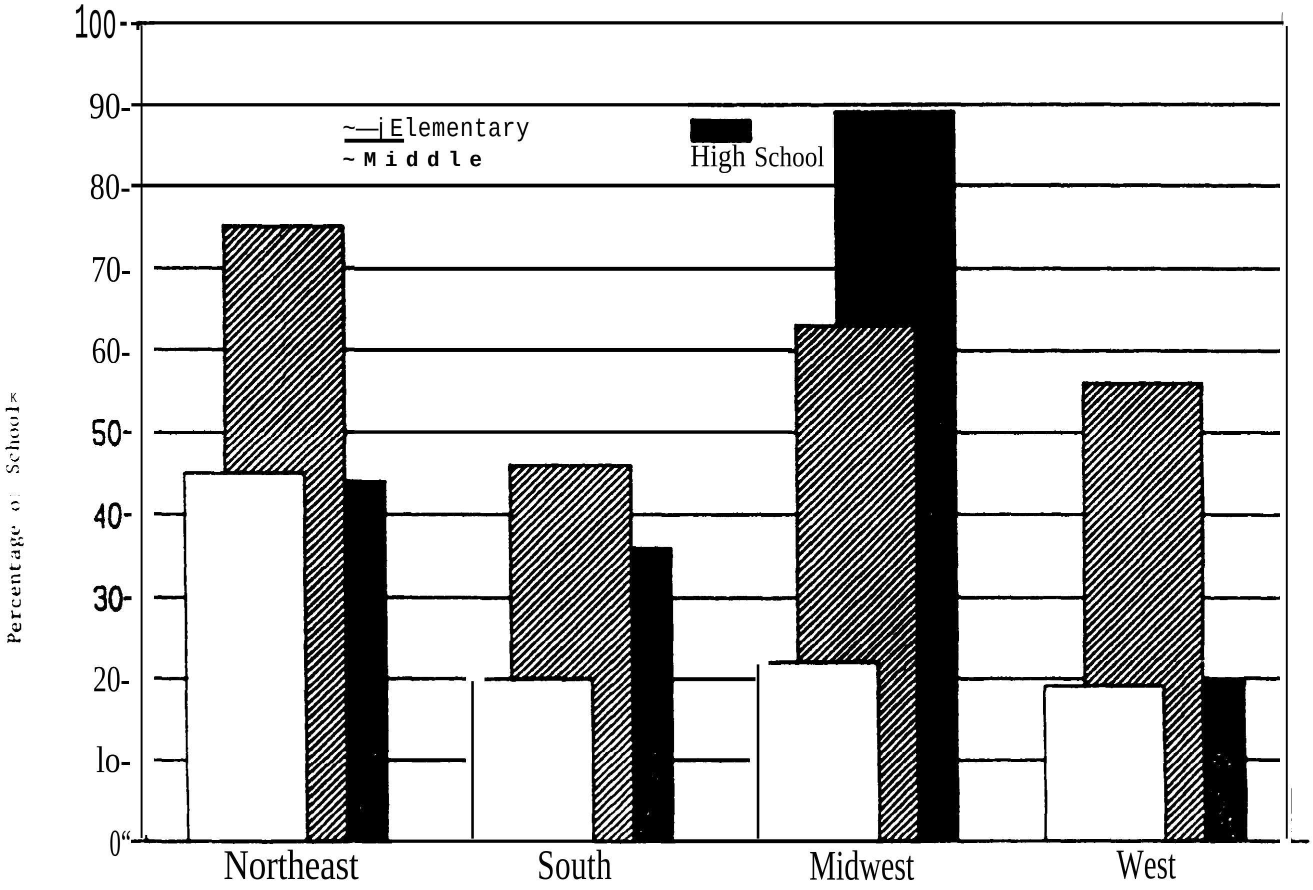
These differences in the degree and timing of courses in computer literacy are especially important because of the growing sense among educational researchers and computer scientists that initial emphasis on computer literacy and programming may have been misguided. The more proper focus of computer-based 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.

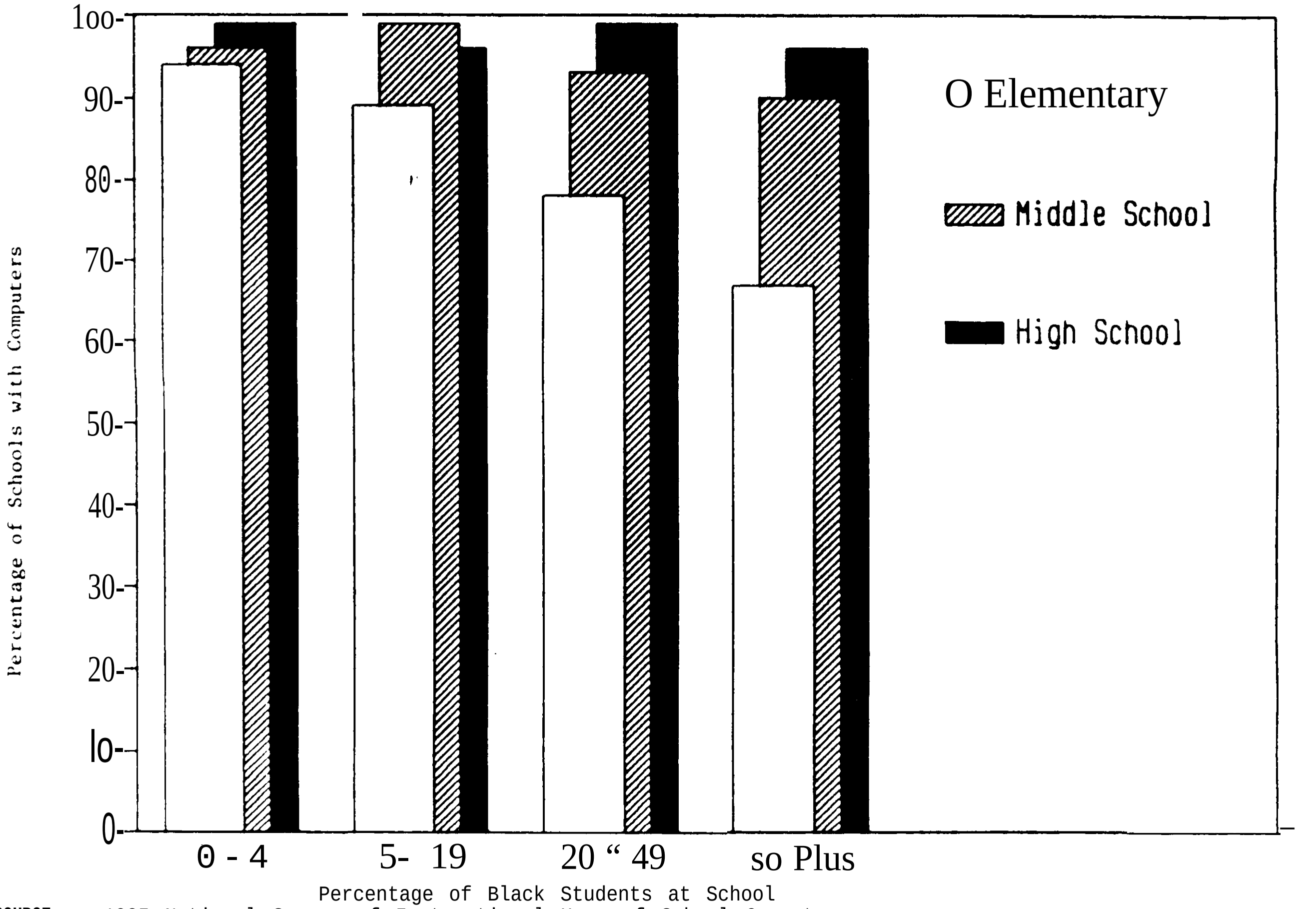
Third, there is no evidence that computers in black schools are used for longer periods of time than those in white schools; thus, not only do black students typically have lower access than whites, they also have less time on the computers than students in predominantly white schools. Note, however, 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 about 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.*

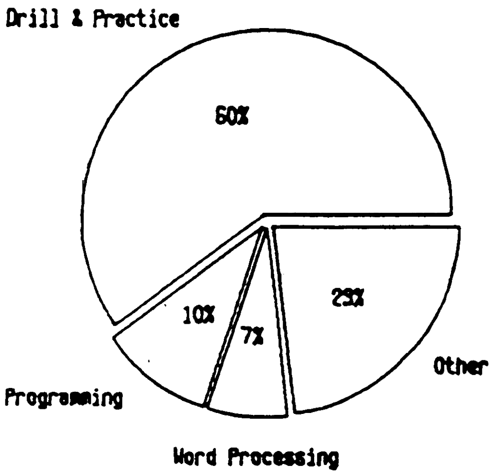
As of 1985, student instructional time spent with computers overall was divided almost evenly between drill and practice, programming, and all other uses, including problem solving "discovery learning") and word processing. In the elementary grades most time is spent with drill and practice, while in 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

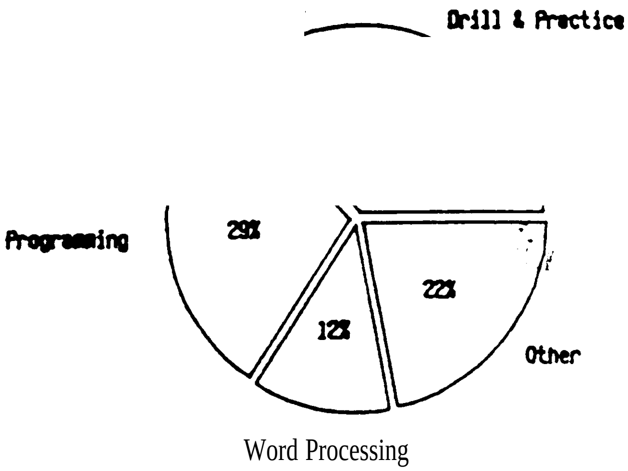
7. EPIE Institute, Teachers College Press, Columbia University, New York, 1986.

* 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.

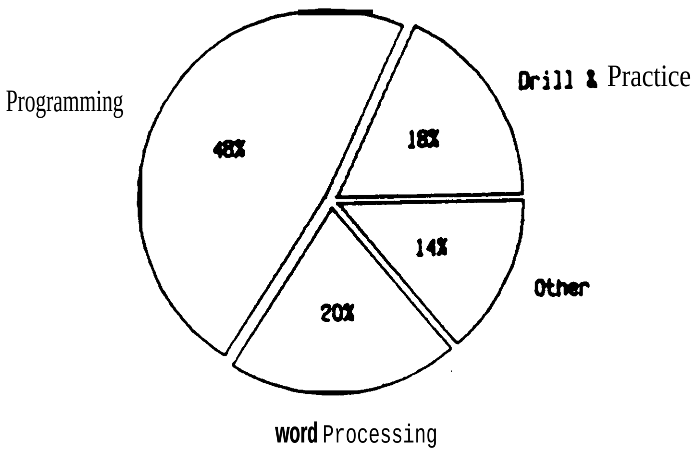
Elementary Students



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.

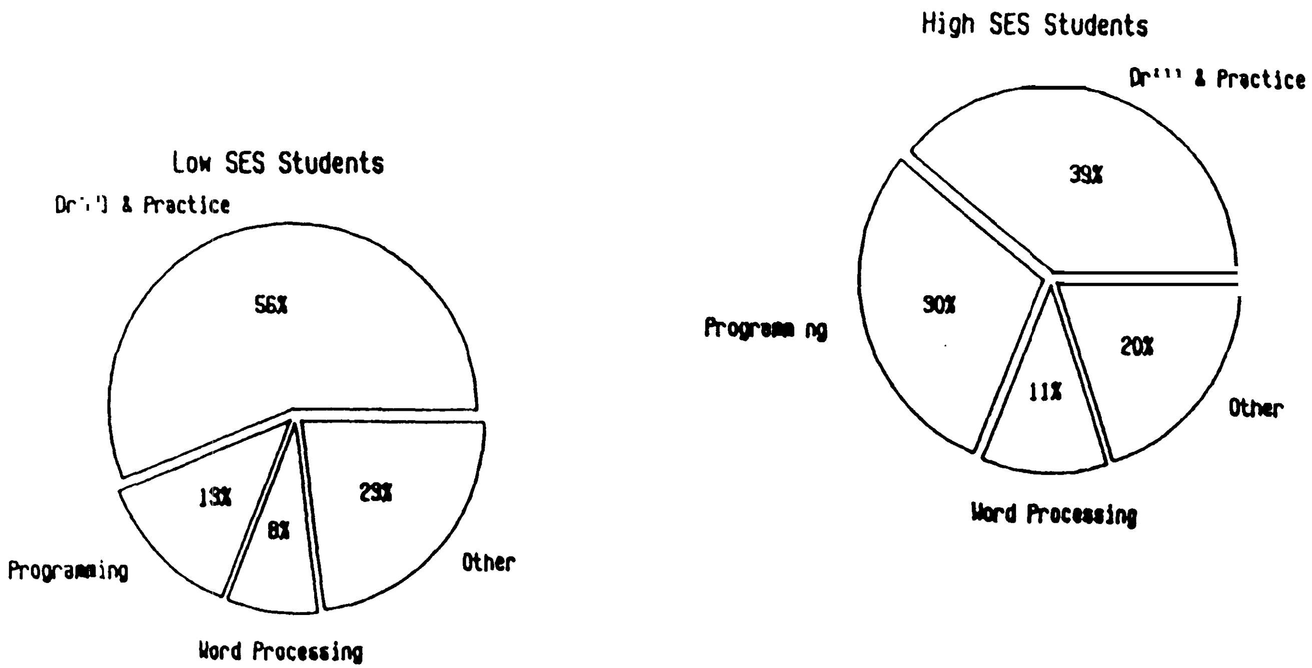
TEACHERS: TRAINING AND EXPERIENCE

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

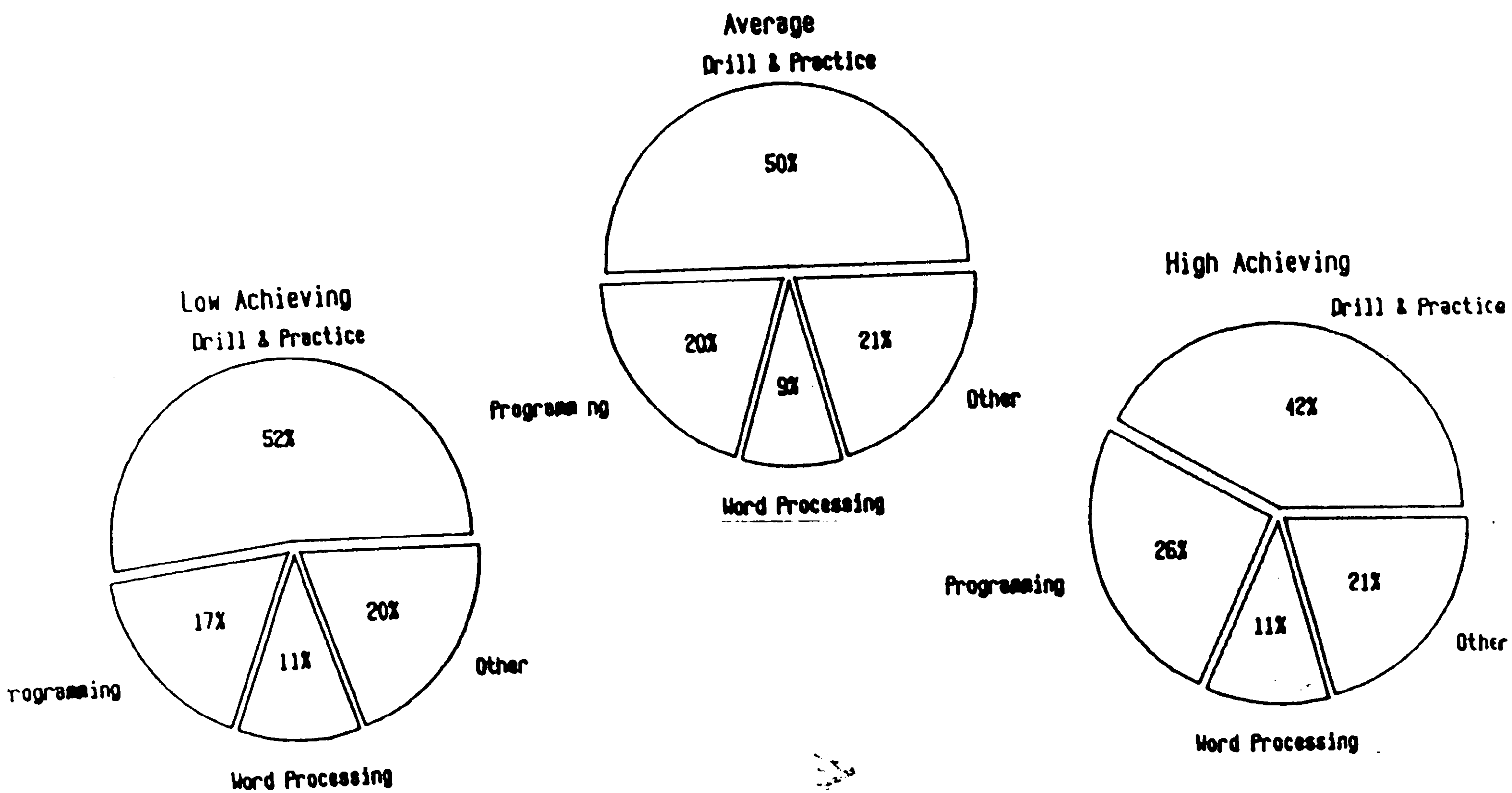
INSTRUCTIONAL APPLICATIONS OF COMPUTERS: VARI BY SOCIOECONOMIC STATUS OF STUDENT



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, Jo-o= 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

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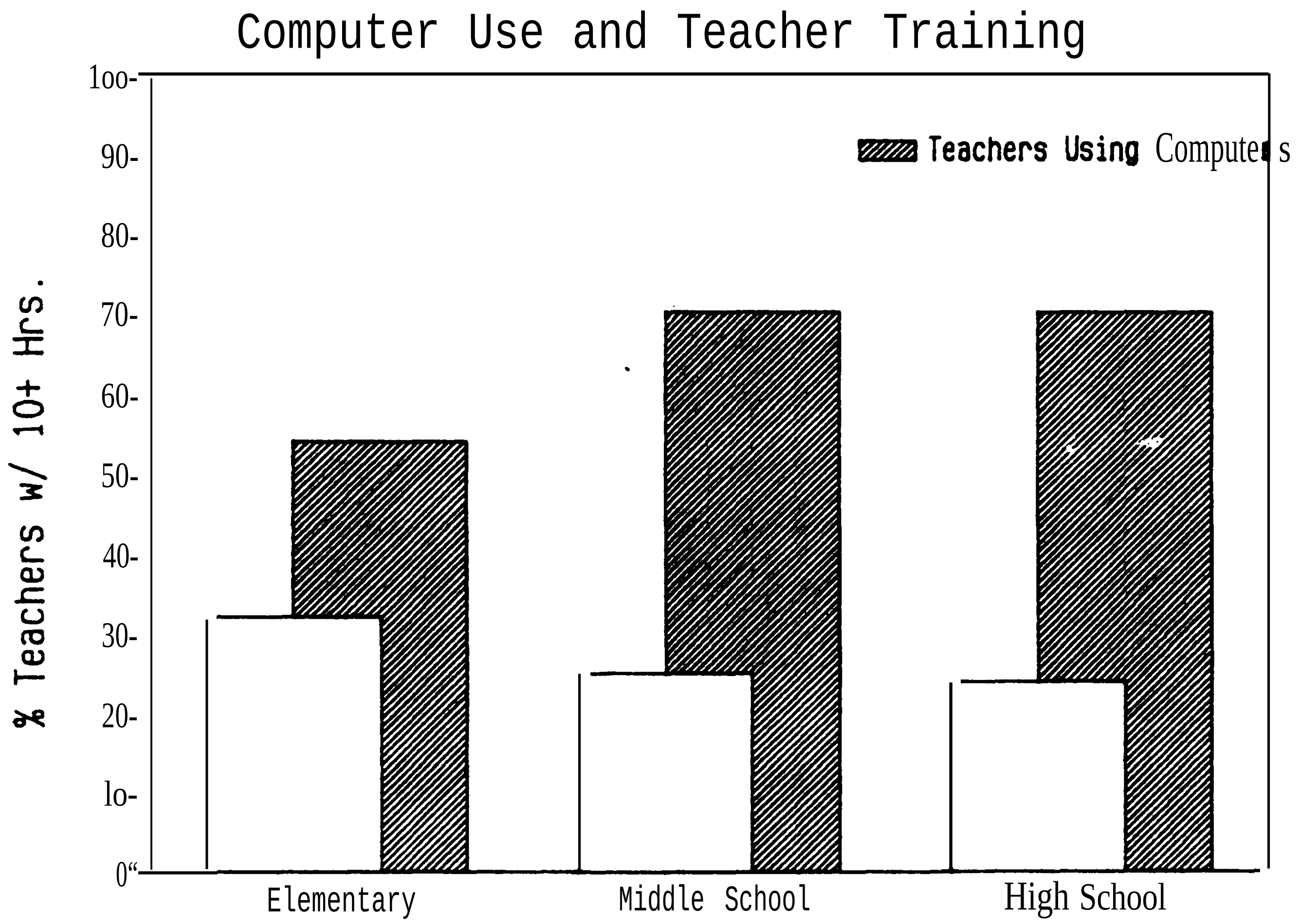
8. 1986 data from the National Survey of ECIA Chapter 1 Schools, conducted by Westat Corporation for the U.S. Department of Education.

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:

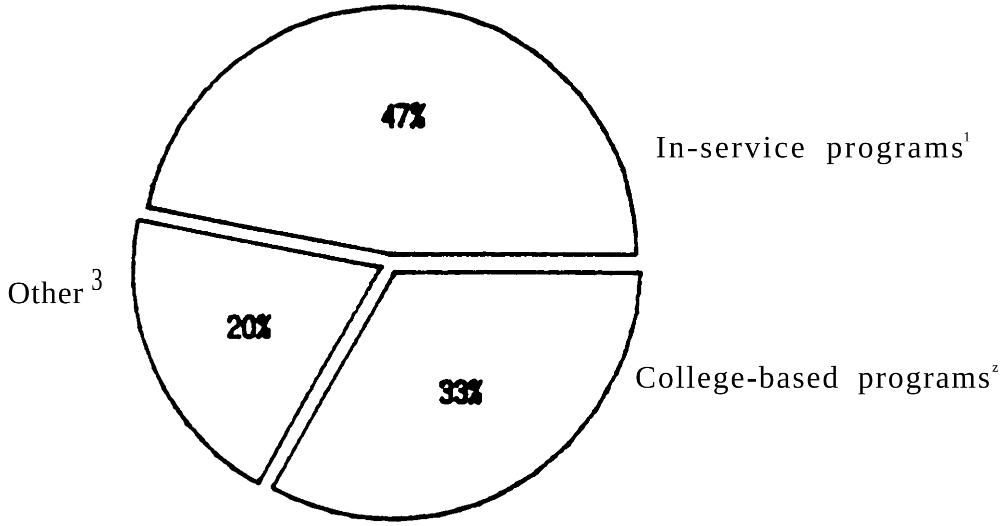
- Where do teachers receive their training? Current data suggest that as many as one-fifth of all teachers who receive training do so from nonschool sources, including manufacturers and vendors of computer equipment. (See figure l-12) While it is often quite valuable to have some involvement by computer 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

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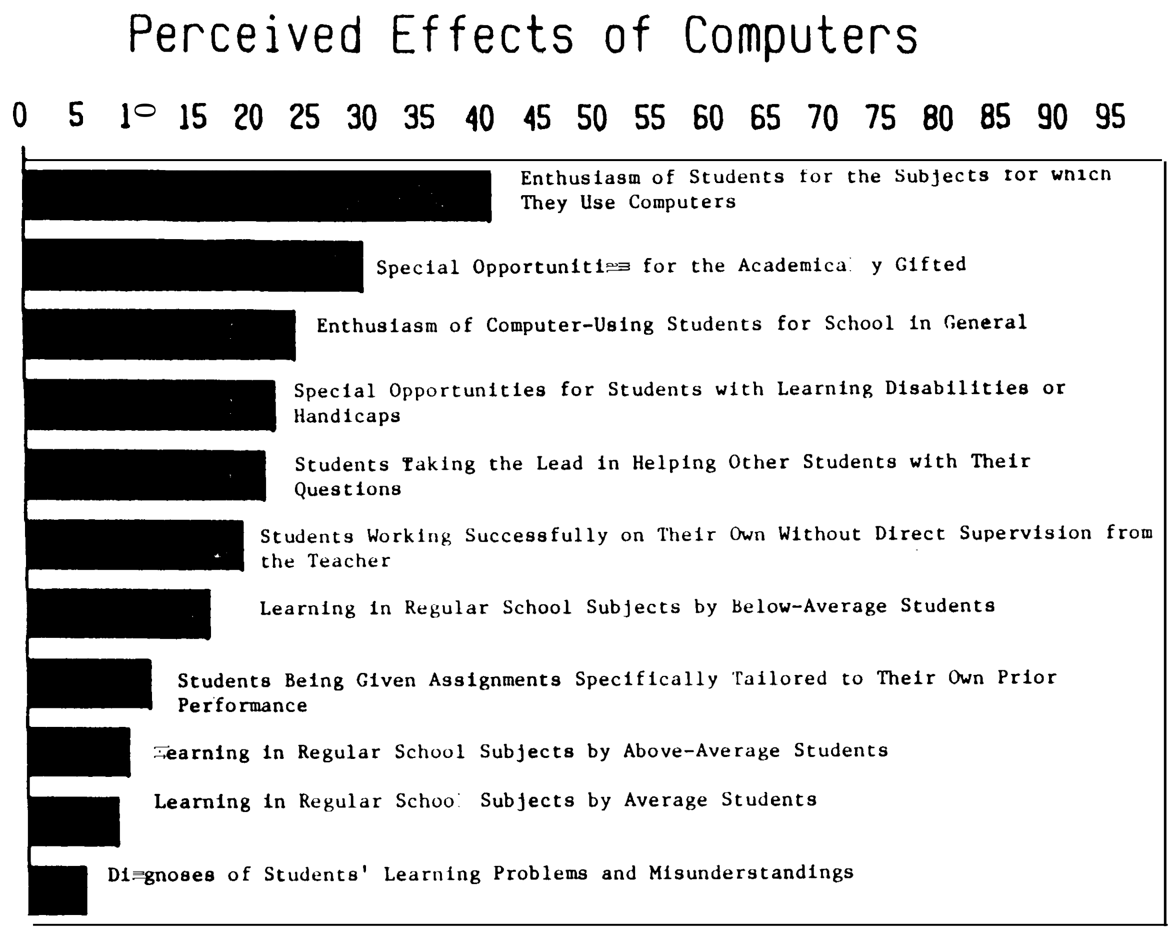
effectiveness, which must be distinguished from studies that concentrate on effects of computers independent of their costs, was the principal focus of Stern and Cox's paper, and will be addressed in a separate OTA document at a later date.

* 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



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 Center for Social Organization School'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 <u>in the school district</u>. 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.