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ABSTRACT

One of a series on the responses by the Educational Testing Service (ETS) and others to critical problems in education, this overview addresses a variety of issues related to computer literacy. Topics discussed include the pace of the transition to the computer age, the development of microprocessors, and the computer as fad or revolution. Problems related to definitions of computer literacy are examined and computer uses in the classroom are described, including projects in innovative schools such as the Waterford School (Provo, Utah) and Lamplighter School (Dallas, Texas), public schools, the Minnesota Educational Computing Consortium, and college computerization projects. A planned ETS program to offer Advanced Placement in computer science is outlined, and a summary of issues related to microcomputers notes problems of inadequate software, software evaluation, and teacher training. Discussions of the impact of computers on education and implications for public education, a description of ETS seminars for elementary and secondary educators, and a glossary conclude this state-of-the-art review. (LMM)

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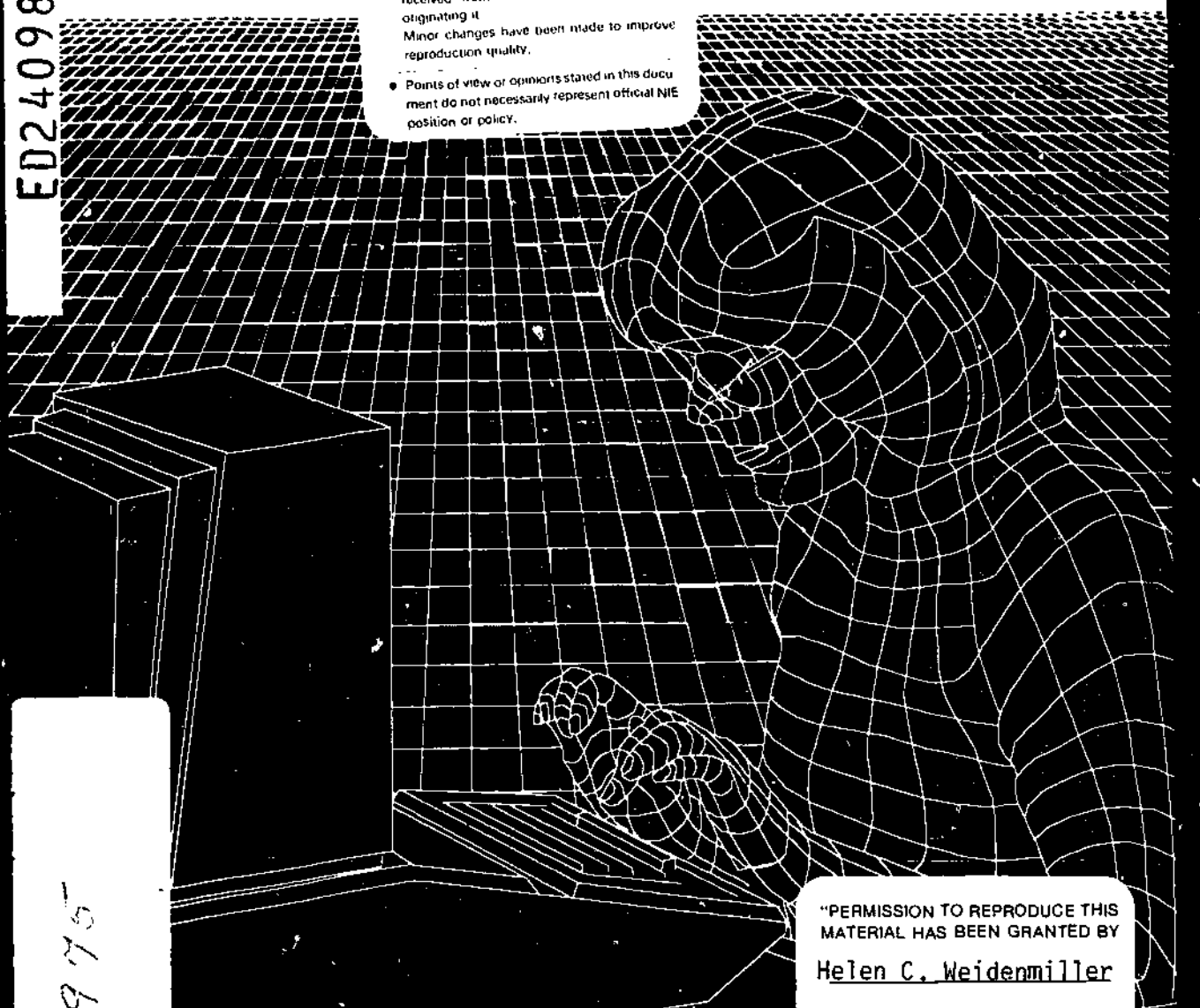

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COMPUTER LITERACY

Focus 11 • 1983 • Educational Testing Service
Editor • Albert Benderson

Each issue of FOCUS discusses a critical problem in education and the work Educational Testing Service and others are doing to cope with it. Most widely known for standardized tests, ETS is also one of the nation's largest nonprofit educational research organizations.

COMPUTER LITERACY

by Albert Benderson

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THE COMPUTER REVOLUTION

Throughout history new methods of processing and communicating information have dramatically enlarged the scope of human knowledge and radically transformed the way people think. The invention of writing, for instance, freed the mind from the burden of rote memorization, vastly multiplying the amount of information at an individual's disposal. The invention of movable type by Gutenberg in 1450 eventually provided the masses with access to ideas and thoughts that had previously been available only to aristocrats and the clergy.

Some say we are now living through yet another watershed period in the evolution of human thought. In less than a century we have seen the emergence of a number of revolutionary technologies that are fundamentally reshaping the way people think and communicate. Film, radio, television, and tape have all played roles in the information revolution, but none so profound as that of the computer.

Although only a few years ago our era was commonly thought of as the atomic age, the likelihood is growing that it will

be remembered as the computer age, when artificial intelligence became an indispensable adjunct of human intelligence in various facets of life. With the development of the microcomputer chip in the '60s and the growing popularity of desktop microcomputers in the '70s and '80s, millions of people now use computers routinely at home, at work, and in school.

The April 25, 1982, *New York Times* reports IBM has predicted that, before long, 75 percent of the work force will need some computer skills to do their jobs. By the end of the current millenium, it is entirely possible that computers will be so pervasive in every aspect of business that only those who can use them with facility will survive in the marketplace.

The pace of this transition into the computer age has caught educators largely unprepared, and experts at every level are now struggling with the difficult problem of how best to prepare children for life in the future. That they have not anticipated and planned for the impact of this new technology can hardly be said to be their fault. Alvin Toffler, one of America's most prominent students of the future, didn't even mention microcomputers in *Future Shock*, published only 12 years ago.

The Incredible Shrinking Computer

The entire history of computer technology has unfolded at an astounding pace in the years following World War II. The first large-scale electronic computer, the Electronic Numerical Integrator and Calculator (ENIAC), built by J. Presper Eckert and John W. Mauchly at the University of Pennsylvania in 1946, was a massive machine, housed in a 30 by 50-foot room, that depended on 18,000 bulky vacuum tubes and miles of wiring to operate.

By the 1980s microelectronics had become so advanced that a computer far more powerful than ENIAC could be designed on a tiny chip of silicon, less than a quarter-inch in size. Costing only a few dollars, these chips, called microprocessors, contain thousands of microscopic transistors. According to Harold G. Shane in a January 1982 *Phi Delta Kappan* article, "The Silicon Age and

Education." By 1980 it was possible to etch the equivalent of 60,000 to 70,000 vacuum tubes on a microchip; by the spring of 1981, in a U.S. laboratory, 750,000 equivalents were squeezed onto a chip.

Microprocessors have enabled manufacturers to develop desktop computers costing only a few hundred dollars that can be used just about anywhere, and they are aggressively promoting the educational benefits of their machines. According to the National Center for Education Statistics, elementary and secondary school students had access to 96,000 microcomputers and 24,000 terminals in the 1982-83 academic year compared to 31,000 microcomputers and 22,000 terminals available in fall 1980. Industry studies project figures of anywhere from 300,000 to 650,000 microcomputers available by 1985. In many places educators are torn between their fear of being left in the dust by the new technology and their uncertainty about how best to use it.

Most teachers and administrators have little or no knowledge of computers and yet must now make decisions on investing in microcomputer technology that could shape the future of an entire generation of students. Questions of almost every conceivable kind loom in every direction. What should students be learning if they are to graduate into a world in which 75 percent of all jobs will involve some contact with a computer? Will all students need to know how to write computer programs? Or will most simply have to know how to utilize programs written by a clever few? Do students who learn programming also learn to think more logically, or do they just learn to think like computers, with little carry-over into other fields? In light of the new enthusiasm about computers, what will happen to the traditional disciplines? If the schools devote time to teaching about computers, they will have to eliminate time devoted to other subjects. Should some subjects, particularly mathematics, be modified in the wake of the new technology?

Stanley Pogrow, in the May 1982 issue of *Phi Delta Kappan*, suggests that "it looks as if computers will have a sufficient hold on U.S. society by 1985 for proper training in their use to replace basic skills as the primary public concern in education."

Revolution or Fad?

Yet, many educators wonder whether computers will be relegated to the pedagogical junk heap in a few years, along with teaching machines, programmed learning, and the new math.

Peter Kelman argues, in the January/February 1982 issue of *Classroom Computer News*, that the microcomputer revolution has been so swift that ". . . there has been almost no time taken to reflect seriously upon the pedagogical, psychological, philosophical, and ethical issues involved in computer-based education, not to mention time reserved for simple quality control."

In the San Francisco area, the Ad Hoc Committee on Basic Skills Education accuses the microcomputer industry of using "scare tactics" to intimidate educators, afraid of being left behind by new technology, into buying their products.

Supporters of advanced technology in the classroom, however, tend to lump critics with those misguided souls who once resisted such inventions as the car and the airplane.

Already, in fact, the demand for computer education may have become irresistible. In "The Digital Generation," an April 29, 1982, Gallup organization briefing paper, Robert Bezilla reports that a May 1981 survey of the general public revealed 43 percent thought computer training should be required for all high school students. Moreover, 55 percent of high school-age students surveyed in fall 1981 believed it is likely they will take computer courses in college. A majority of teenagers from all demographic groups expected to study computers in college and, in fact, a greater percentage of blacks (61 percent) reported an interest than did whites (55 percent).

From 1980 to 1981, a career in computers and electronics vaulted from tenth place in popularity among teenagers of both sexes to fourth among boys and sixth among girls. Educators clearly are going to have to make important decisions about the role of computers in the public school curriculum fairly soon. As Alvin

Toffler puts it in an interview in the April 1981 issue of *The School Administrator*, "If the schools have any function, any justification, it is to prepare young people for the future. If it [sic] prepares them for the wrong future, it cripples them."

Those who support computer education argue that students, in order to be properly prepared for the right future, will have to achieve "computer literacy." Like other educational buzzwords of the past, the term has been widely used by technicians, educators, and computer hucksters, but it is rarely used the same way twice. Almost every expert in the field has his or her own favorite definition of computer literacy.

"Computer literacy has become a buzzword which lacks meaning in an educational setting."

Nevertheless, defining the term is no trivial matter. The manner in which computers are incorporated into an institution's curriculum is usually a reflection of some key administrator's definition of what students will have to know in order to be truly literate in the computer age. At best, it might be said that computer literacy is most generally understood to connote a threshold of knowledge that qualifies an individual for participation in the computer age. Where the threshold lies is a matter of considerable dispute.

Bruce Taylor, director of development planning at ETS, dislikes the term "computer literacy" altogether. "Computer literacy has become a buzzword which lacks meaning in an educational setting," says Taylor. "It is yet another example of the computer fraternity's rather astonishing ability to bastardize the language. Literacy is an intellectual concept, denoting a skill—reading and writing—in its specific sense; for some reason we have attached it to a device. Logically, we could speak of programming literacy, but to talk of computer literacy is as absurd as speaking of automobile literacy or washing-machine literacy.

"The confusion that surrounds the term today could be largely eliminated if the computerists and the educators were a bit more precise. If we mean to teach computer programming when we talk of

teaching computer literacy, then say so. But if we mean to teach students to be aware of or understand computers and how they work, why not simply say so?"

"While some may want to teach programming to all students," says Taylor, "most would agree that it is not a reasonable objective for everyone to become programmers just because computers will be widely used, any more than it is necessary for everyone to become doctors because we all become ill at one time or another. It is, however, vital for students to understand why and how computers work and to be aware of their impact on society."

Martin Schneiderman, director of the ETS Technology Laboratory, agrees, saying, "Many educators are placing undue emphasis on teaching students to write computer programs. In most high schools computing remains almost synonymous with the teaching of programming languages, despite the fact that outside of schools, the vast majority of computer users are not programmers. In the guise of teaching people how to use computers, we teach BASIC. Although programming knowledge is not required to operate a computer, we seem to do our best to make it so.

"We need to help children identify real problems they can solve using readily available commercial software as well as high-level programming languages. Through using word processing, data base management and graphics programs, students can be taught more about computers and computing than many educators realize. *We* are the critical software."

Arthur Luehrmann, however, disagrees. A leader in the field of computer education, he writes in the December 1981 issue of *The Mathematics Teacher*, "Literacy, in a language, means the ability to read and write, that is, to *do* something with language, not merely to *recognize* that language is composed of words, to *identify* a letter of the alphabet, or to be *aware* of the pervasive role of language in society. . .

"By analogy, computer literacy must also mean the ability to *do* computing, and not merely to recognize, identify, or be aware of alleged facts about computing."

"Most educators are placing undue emphasis on teaching students to write computer programs."

In the December 1981 issue of *Popular Computing*, Luehrmann is quoted as equating computer literacy with programming. "The goals of a computer literacy program," he says, "are to teach programming and programming skills, new ways of thinking, planning skills, and debugging strategies."

A Broad Definition

In the same issue of *The Mathematics Teacher* containing Luehrmann's remarks, Ronald E. Anderson, Daniel L. Klassen, and David C. Johnson reply, criticizing his definition of computer literacy as a "narrow view." Literacy, they argue, includes both the ability to perform—i.e., read and write—and the state of being informed, "cultured," well-versed.

"In defining computer literacy," they write, "it is useful to distinguish it from computer science. The most succinct distinction is to say that computer literacy is that part of computer science that everyone should know or be able to do. . ."

"For example, people need to know enough about computer systems so as not to be intimidated by a computerized billing error; people need to know whether to acquire computer equipment for home or work; people need to know how to evaluate when computer applications are helpful and when they are harmful; and so forth. Some of these things can be learned as a byproduct of learning to write simple BASIC programs, but most of this type of useful knowledge cannot be learned that way. Indeed we would argue that most of what every ordinary citizen needs to know about computers will not be learned from learning how to program."

Glenn Polin, educational marketing director of Apple Computer Inc., also thinks that some educators place an undue emphasis upon teaching students to program computers. He compares the computer literacy crisis to the "automobile literacy crisis."

"We are all users of devices, such as the television and telephone," he says, "and a user of a device doesn't need to understand everything about how the technical aspects of the device work. Do we want everyone to be programmers? I think the answer to that in the future is going to be increasingly no, just as not everybody needs to be a mechanic to use an automobile. While there is now some emphasis on learning to program, eventually the emphasis is going to go toward using the machines.

"What does it mean to use a computer? Increasingly, future applications will be user-friendly and will not require an intimate knowledge of the computer. The software evolution of the last three or four years bears that out. We have packages on the market today that can be used by a total novice, by a secretary with no training, by a manager with no training, and that trend is accelerating. When you go out into the world, you're not going to be asked to do basic programming unless you choose that as a vocation."

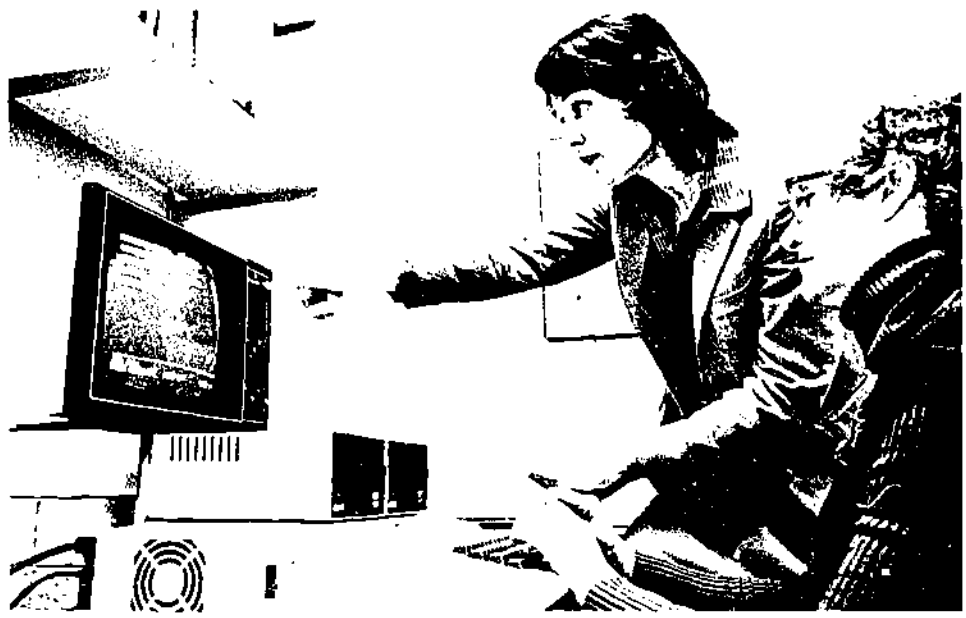
Multiple Definitions

The split between those who believe that programming should be the centerpiece of any computer literacy program and those who favor a broad approach with relatively little or no attention to programming is not likely to be resolved until it becomes more evident what degree of skill in operating computers will be essential for most people in the future.

In fact, a computer literacy survey being developed by ETS and the Human Resources Research Organization (HumRRO) for the National Center for Education Statistics (NCES) is based on the assumption that computer literacy should be defined differently for divergent groups of people.

The survey will consist of a pool of 250 questions that can be used by states or school districts to assess the computer literacy of elementary and secondary school students, teachers, and administrators when making decisions on staff development, learning materials, hardware and software acquisition, and educational policy. The questions are drawn from eight separate domains of computer literacy, ranging from teaching with and about computers to writing computer programs to understanding computer-related social issues.

According to ETS project director Marlaine E. Lockheed, computer literacy may be defined differently for various groups depending upon which of the



"... the future issues include not only what is computer literacy, but what types of skills are appropriate for what types of learners."

domains they need to master. "Computer literacy for teachers," she says, "may include the ability to teach about computers, while computer literacy for students would not include this skill. Thus, the future issues include not only what is computer literacy, but what types of skills are appropriate for what types of learners."

COMPUTERS IN THE CLASSROOM

Educators who invest in computer technology will have to confront these issues in order to decide how best to use the machines in the classroom. There are basically three different ways to approach computer education. The first, and most widespread, consists of using the computer as a tutor, an approach commonly known as computer-assisted instruction (CAI). The software is programmed by experts in the subject area, and the student is tutored by executing the program. Typically the computer presents the subject material, the student responds, the computer evaluates the response, determines the next presentation, and keeps a record on each student. CAI programs include drill-and-practice routines, learning games, and certain types of interactive tests.

Other programs enable students to use the computer as a tool rather than as a tutor. A student, for instance, may use the computer for word processing, calculation, musical performance, statistical analysis, data retrieval, or record management. Simulation or modeling programs are among the most innovative in this category. They enable students to reproduce real-life situations for study on the computer. Programs have been developed to enable chemistry students to simulate experiments too hazardous or time-consuming to attempt in the lab. Others enable biology students to simulate environmental problems, such as the

effects of pollution on fish populations or the difficulties encountered by whales during migration. In the military, simulations enable planners to reproduce battlefield conditions on the computer in order to gauge the effects of various weapons and strategies.

The third approach involves making the computer serve as the tutee. Here the student educates the computer. The student must learn how to program the machine and must master the subject material to be taught to the machine. Using simple programs, young children can program computers to draw geometric shapes. Experts have been able to program computers to compose music and diagnose illnesses. Learning how to program enables students to understand how computers work, and typically this application occurs in computer literacy programs and computer science courses.

Many schools around the country have already instituted ambitious programs in computing. Some use the devices mainly for computer-assisted instruction in traditional subjects, while others focus on learning about the computer itself. A National Center for Education Statistics report indicates that senior high schools chiefly use computers in computer science courses; middle schools for remedial instruction, learning enrichment, and computer literacy; and elementary schools for learning enrichment, compensatory instruction, and basic skills instruction.

At the elementary level, computer manufacturers have played a key role in developing the curriculums at two innovative schools. One manufacturer of computers and interactive videodisc systems, the World Institute for Computer-Assisted Teaching (WICAT), has established its own small private school—the Waterford School in Provo, Utah—to demonstrate that computers can enhance the effectiveness of education in every subject area.

During the 1982-83 academic year, 215 students are attending kindergarten through eighth grade at the school tuition-free. They spend about an hour and a quarter per day working on reading, writing, and math with the school's 30 terminals connected to a central computer.

The Waterford system is used strictly for individualized computer-assisted instruction (CAI) rather than for teaching computer literacy. Some teachers structure their classes as demonstration lessons using the computer for drill and practice, while others use it to allow students to move through the curriculum at their own pace.

"One of our dreams," says William B. Fisher, director of WICAT's Basic Division, "is that we will see more substantive concepts introduced at earlier ages into the schools generally."

WICAT's software packages, therefore, go beyond conventional drill and practice exercises, forcing the students to reflect upon and defend their answers. In one reading program, students must answer questions about the content of a paragraph they have read and then indicate which key words led them to their choices. In another, students must evaluate an author's argument, differentiating fact from opinion, determining which hypotheses have to be proved by the writer in order to make his case, and stating whether or not those hypotheses are supported and substantiated by the text. Using the computer, the teacher can monitor the individual progress of each student while being relieved of burdensome paperwork.

The Lamplighter School in Dallas, Texas, is another small private school (kindergarten through fourth grade) with an ambitious computer education program spurred by close ties with a computer manufacturer. Lamplighter, however, uses the technology in a manner that is fundamentally different from that of the Waterford School. The focus of the school's $400,000 computer education project, developed in conjunction with Dallas's Texas Instruments computer firm and the Artificial Intelligence Laboratory of the Massachusetts Institute of Technology, is on programming as well as CAI. Lamplighter's 413 students frequently tell the computer what to do rather than merely following its instructions.

At the heart of the curriculum are 50 Texas Instruments 99/4 computers and LOGO, a unique programming language developed by Seymour Papert of MIT. In his book, *Mindstorms*, Papert makes a clear distinction between the LOGO

philosophy, which has shaped the Lamplighter School curriculum, and CAI. "In many schools today, the phrase 'computer-aided instruction' means making the computer teach the child. One might say the *computer is being used to program* the child. In my vision, *the child programs the computer* and, in doing so, both acquires a sense of mastery over a piece of the most modern and powerful technology and establishes an intimate contact with some of the deepest ideas from science, from mathematics, and from the art of intellectual model building."

Preschoolers and first-graders at Lamplighter use LOGO as an instructional aid and for them. Lamplighter teachers have developed a series of programs covering color recognition, block building, shape comparisons, and motor coordination. Older children write programs in order to learn basic concepts in geometry and mathematics by maneuvering a small figure, called a Turtle, so that it traces various geometric patterns on the video screen. In the process they also learn about the computer and develop the habits of logical thinking inherent in programming activities.

"According to Piaget," says Texas Instruments Educational Marketing Manager John Alden, "a child's learning and developmental sequences begin in a concrete fashion and move toward abstraction, and that's what LOGO does. Children first begin learning how to tell a Turtle to move 45 or 90 degrees and end up being able to write algorithms that are as sophisticated as the programming a lot of adults can do."

Students have free access to school computers and use them whenever time is available. Many arrive early or stay quite late in order to use the machines, a phenomenon observed at many other schools across the country.

Public school educators have also been impressed by the enthusiasm of students for programming in LOGO as well as their progress in learning advanced mathematical concepts and in achieving computer literacy. Gene Biringer, principal of the Riverside Elementary School in Princeton, New Jersey, where fourth- and fifth-graders are learning to program in LOGO, says that with LOGO, students learn geometry intuitively.

"These will be the best geometry students we have ever seen," says Biringer, "and geometry is really a fringe benefit of LOGO. The important thing is that the students are in control from the first day they sit down at the computer. That was our basic concept. On the first day our students work with the computer, they program a square. That's powerful. The machines can't be controlling the students: we get too much of that in our lives."

Biringer also suggests that LOGO helps students to think more logically. "You can't write a program without setting up a logical sequence of instructions. Otherwise you get garbage. Students learn to see the whole as the sum of its parts, and this carries over into other activities such as writing stories."

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Like Princeton, school districts throughout the country are integrating computers into their curriculums, although budgetary limitations frequently prevent the intensive use characteristic of the Waterford and Lamplighter Schools. A September 1982 survey by Quality Education Data, Inc., revealed that 46 percent of U.S. public school districts now own microcomputers. The figures are even more dramatic if one looks at individual schools using microcomputers, since microcomputer ownership is generally characteristic of the larger districts. Nationally, 63 percent of all schools (53,351), enrolling more than 80 percent of all pupils, are in districts with microcomputers.

Moreover, despite the popular notion that teachers are fearful of microcomputer technology, an October 1981 *Instructor* magazine survey of subscribers indicated a high level of interest among 86 percent of the 4,000 who returned their questionnaires —even though 59 percent don't use microcomputers for instruction, generally because of lack of access. Although it is quite possible that teachers highly interested in computers were more likely to complete the survey form, the fact that 50 percent reported having taken computer courses on their own is still impressive.

One of the most ambitious computer literacy programs was launched, according

In many high schools throughout the country, academically talented students can obtain college credit by taking Advanced Placement courses in various subjects and then obtaining a sufficiently high score on a College Board Advanced Placement examination developed by ETS. Starting in May 1984, the College Board will offer an Advanced Placement examination in computer science.

One of the primary motivations in creating the exam was to help develop a national standard for the teaching of advanced computer science courses in high school. Thus, the Examination Development Committee, composed of college and high school teachers, has also designed a course description it expects most high schools to follow when establishing computer science courses.

The most striking feature of the course description is that the committee has recommended the teaching of Pascal rather than BASIC—the most widely used microcomputer language. "The guiding principle," says ETS's examiner J. R. Jefferson Wadkins, "is to teach a language that the colleges will give credit for. The vast majority of colleges would never give credit for a course in ordinary BASIC because it is not a structured language. Pascal is the only structured language widely available on microcomputers."

Since the examination will be based upon the course description, students without a knowledge of Pascal would have great difficulty doing well.

Carl Haag, ETS director of the AP Program, points out that the committee is not attempting to dictate that all high school computer courses abandon BASIC. "We are talking about AP courses at only 300 to 400 schools out of 23,000," says Haag. "We have no advice for any other courses."

Haag concedes that many teachers hoping to teach the Advanced Placement course may be unfamiliar with Pascal, but he hopes that teachers will be able to attend one of the 48 summer school courses to be offered nationwide in 1983.

One of the primary motivations in creating the exam was to help develop a national standard for the teaching of advanced computer science courses in high school.

to the March 1982 *American School Board Journal*, in the Lyons Township high school district of LaGrange and Western Springs, Illinois. Soon after John Bristol became superintendent in 1980, he convinced the school board that computer literacy should be a top educational priority for all students. A quarter-million dollars was allocated for the purchase of 220 microcomputers—enough to equip eight labs for the system's 3,800 students. When a class uses the computers, each student has his or her own machine.

Bristol envisioned a pervasive computer literacy program relating to all subjects in the high school curriculum, and all but two of the district's 275 teachers participated in an inservice computer literacy course during the spring preceding the introduction of computers into the classrooms. Working together with experts on the faculty and computer whizzes from a nearby college, many teachers soon began producing software geared to their own courses.

"Some people build a program around available software," says Bristol. "We built our computer literacy program around our own needs."

"In the long run, a segment of our society may be denied these options because they will have had no contact and no familiarity with high technology."

Some have argued, however, that while relatively affluent school districts such as Lyons Township can afford ambitious computer literacy programs, middle-class and low-income districts lack the resources to support such innovations.

A few experts have predicted that computers may only further exacerbate the division between the haves and the have-nots in American education. Ernest J. Anastasio, vice president for research management at ETS, suggests that the day is fast approaching when anyone who is not familiar with computers will be as economically disadvantaged as those who cannot read or write are today.

Anastasio fears that, if schools in low-income districts are unable to afford computer courses, many students in those areas will have important options closed to them. "I don't agree that everybody has to become fluent in programming computers," he says. "To the extent that computer technology continues to pervade all aspects of our lives, those people who

have some skills in dealing with it are going to be better off than those people who don't have the skills. Microprocessors are in TV sets, toasters, ovens, watches, automobile engines, and telephone answering machines. People who know something about designing, manufacturing, installing, maintaining, or simply using the equipment are going to have more options in their lives. They're going to be in more powerful positions. They're going to be paid more."

"In the long run," he adds, "a segment of our society may be denied these options because they will have had no contact and no familiarity with high technology. These are likely to be the children who grow up in major urban areas. On the other hand, children in the more affluent suburban communities will have more familiarity with the technology, and they will be the ones who have access to better jobs, better education, and the like."

There are some indications, however, that microcomputer costs have now decreased to the point where even urban districts with tight budgets can afford computer literacy programs. The October 26, 1982, *Christian Science Monitor* reports that Boston school officials have purchased or leased 185 microcomputers and are building computer labs in 15 schools. Detroit has purchased 300 computers and Houston 400, with plans to buy an additional 200 this year.

The *Monitor* also points out, however, that the gap between low-income and high-income districts persists. Among schools spending less than $30 per pupil on instructional materials, only 22 percent have microcomputers. Among schools spending more than $60, nearly 40 percent have the machines.

Nationwide only one computer is available for every 400 students and most are concentrated in relatively affluent areas. A study by Market Data Retrieval, of Westport, Connecticut, revealed that 80 percent of the 2,000 largest and wealthiest districts have at least one educational computer, whereas this is true for only 40 percent of the 2,000 smallest and poorest districts.

Another distinction between wealthy and poor districts arises from the way in which they use computers. According to the *Monitor*, "Wealthy schools tend to use computers to teach advanced skills, such as programming. Innercity and rural schools are more likely to simply drill students in the three R's."

In an effort to help bridge the technology gap between the rich and the poor, the U.S. House of Representatives, in 1982, passed a bill aimed at encouraging manufacturers to donate computers to elementary and secondary schools by granting them a huge tax write-off on the equipment. The bill died in the Senate, but new versions have been introduced in both houses of Congress this year. One of the bills contains a provision requiring that 75 percent of a corporation's contributions be to school districts where parental income falls below the national median.

IBM, however, has decided not to wait for a tax break before donating computers to the schools. On March 12, 1983, it announced that it would donate approximately 1,500 IBM Personal Computers and necessary software to 12 teacher-training institutions and 84 public and private secondary schools in California, Florida, and New York as part of a new $8 million philanthropy program.

Rather than just tossing computers at the schools, IBM will provide teacher-training and support networks to ensure that the secondary schools derive maximum use from the computers. Four teacher-training centers will be located in each state as the hub of a network of seven or eight schools. Some of the teacher-training institutions will be education schools at various colleges, while others will be schools or districts that have developed effective programs for the use of microcomputers. The networks will also include major IBM facilities in each state that will provide technical support for the project.

All 12 networks will be linked to the ETS Educational Technology Group in Princeton, New Jersey. ETS has been chosen by IBM to assist in selecting both the teacher-training facilities and the participating schools. Schools will be chosen to represent a broad cross-section of economic, ethnic, and social backgrounds. "We want to be certain that the model we create can be used by schools that are not affluent as well as those that are," says ETS project director Hugh F. Cline.

ETS also will provide training and support to the staffs of the teacher-training institutions. During the spring, ETS will conduct a two-week series of workshops and seminars for staff at the teacher-training centers. They will, in turn, train one administrator and at least three teachers from each of the schools during special four-week summer training sessions. School personnel will learn how to use computers and how to effectively teach students to use them. It is expected that the schools will begin offering computer courses using the IBM equipment in fall 1983.

Approximately 15 computers will be donated to each participating institution along with substantial software, including higher-level programming languages, electronic spreadsheets, word processing, data base management, and graphics packages. All schools will receive high-resolution color monitors. The teacher-training centers will receive one printer for every two computers, and the high schools one for every four computers. IBM will also provide cash grants and the requisite technical support to the teacher-training institutions.

"IBM is not simply dropping off the hardware and software at the schools and then disappearing," says Cline. "The IBM system engineers, the teacher-training people, and our staff will work closely with the teachers throughout the school year. We will encourage monthly network meetings so that teachers can share information, and we will help arrange for student computer fairs to promote as much interaction as possible among everyone in the program."

The overall objective of the program is to help schools determine how to derive maximum benefit from the introduction of computers into their curricula. "We expect that this effort will provide a base of experience upon which parents, teachers, administrators, and industrial organizations can build to bolster instruction in all fields —particularly science and mathematics," says Lewis M. Branscomb, IBM vice president and chief scientist. "The result we are aiming at is a nation better prepared for the technological opportunities in the years ahead."

"This is the most significant project of its kind I've ever seen," says ETS Vice President Anastasio. "I think it will put IBM

and ETS in the unique position of being able to influence the direction of computer education in the United States. In a sense, we will be helping to create a generation of teachers who are familiar with the latest hardware and software—and how to use them effectively as part of the teaching/learning process."

In a similar vein, Steven Jobs, chairman of Apple Computer Inc., has announced that his firm plans to donate computers to 10,000 California schools under a state tax-break law similar to the one proposed in the House of Representatives.

The Minnesota Consortium

Although the goal of the House bill is to put at least one computer in every school in America, one state has achieved that goal within its borders. Minnesota, through its Minnesota Educational Computing Consortium (MECC) headquartered in St. Paul, has emerged as the nation's vanguard state in educational computing. The consortium was created in 1973, and from the beginning state universities and colleges worked with elementary, secondary, and vocational education schools to implement the plan.

Today, participating universities and schools provide more microcomputers per capita than are available in any other state. This widespread availability of microcomputers is largely the result of MECC's ability to offer the machines at substantial discounts to participating institutions. According to MECC spokeman Tom Boe, the organization has distributed 5,000 Apple computers and 1,000 Ataris to Minnesota schools, providing virtually every school in the state with access to microcomputers.

MECC offers a wealth of other services to its member schools, including teacher-training programs, inservice workshops, and a library of over 700 computer programs and related materials. The software library, designed for use with the Apple and Atari computer systems, includes some of the most innovative programs developed anywhere in the country. Software can also be designed specifically for individual courses at the request or suggestion of instructors.

For instance, one of the most popular MECC software packages is "Oregon," a program that enables social studies students to simulate the journey of a pioneer family westward along the Oregon Trail. At the start of the journey, the student must purchase provisions including food, clothing, and buffets. On route, the student hunts deer for the family and fights off various types of desperadoes, all via animation. Should he or she use up all the supplies before the journey ends, the family dies. The simulation provides students with a sense of the hardships families faced while journeying westward and also teaches them a life-or-death lesson in budgeting.

Larry O'Brien, data processing coordinator for the Grand Rapids, Minnesota, school district—a district with 83 computers—says, "MECC is a fantastic asset to the public schools. We wouldn't be where we are without it. It provides excellent software and workshops, and I always have someone to call for help and advice, if needed."

A number of schools and school districts in the United States, Canada, Australia, Kenya, Scotland, and Switzerland have purchased institutional memberships in MECC. Institutional members gain access to all MECC software and support materials along with training in their use. As in Minnesota, discount prices on hardware are available.

Computerized Colleges

While MECC seems to be showing the rest of the country how to promote and coordinate computer literacy programs on a statewide basis, various innovative colleges are developing computerization projects that could turn out to be the landmark programs of the decade in higher education.

Carnegie-Mellon University received the earliest and strongest publicity when it announced, in the fall of 1982, that it had signed an agreement with IBM that would provide 7,500 computer "work stations" for its faculty and 5,500 students by 1991. A three-year development plan calls for several thousand advanced personal computers to be available to faculty, staff, and students by 1986. All computers will be networked to each other as well as to the university's central computer facility so that students and faculty will be able to

gain access to their work through any machine on campus.

Eventually every student will have a computer in his or her dorm room or apartment. Beginning in 1985, each freshman, including those in fine arts, will have to purchase a computer, but the university has not yet decided whether students will be asked to pay the full cost or the university will pick up part of the tab.

Similarly, Drexel University in Philadelphia has announced that it will require all entering freshmen to purchase or have access to microcomputers beginning in the fall of 1983. Students will either purchase computers at discount prices or use machines available in computer labs for those who choose not to buy their own. Unlike Carnegie-Mellon, the computers will not be linked in a network. School officials expect that students will be able to turn in homework and other assignments on floppy disks. Video monitors will be available in classrooms and other key areas, and banks of printing machines will be available for students needing printed copies of their work.

Although Carnegie-Mellon and Drexel emphasize science and engineering, the computers will be used for a wide variety of purposes ranging from simulating science experiments to analyzing literary styles to processing data in the social sciences. In most fields, microcomputers will also be used for word processing and editing. All students will graduate with a high degree of computer literacy, whatever their major.

Other colleges, including Rochester Institute of Technology and Hamline College in St. Paul, Minnesota, have made computer literacy a graduation requirement, and a number of other colleges are considering this policy.

Although computers are increasingly being used in schools to teach students subject matter in almost every conceivable field, they also have a variety of other educational applications. ETS, for instance, has developed a program that counselors can use to help guide students in their career decisions.

The System of Interactive Guidance and Information (SIGI) was designed to help two-year and four-year college students make career decisions by helping them clarify their career goals and values. Once these are established, through a series of interactive exercises, the program indicates careers consistent with a particular student's values and provides answers to 28 different questions about each occupation, covering such topics as educational requirements, income, opportunities, and working conditions.

SIGI is a highly complex program and originally could be handled only by relatively expensive minicomputers, making it difficult for most institutions to offer the service. It has since been reprogrammed for use on the TRS-80 Model II microcomputer manufactured by the Tandy Corporation, and it will be available on the IBM Personal Computer in the future. Currently available at over 250 educational institutions, its popularity is mushrooming.

The SIGI data bank is updated annually and is constantly being refined. A new feature provides a detailed description of 275 different fields of study. Students can learn the kinds of courses they would have to take to prepare for a career in each field, as well as the skills and concepts they would have to master.

An adult version of SIGI is being developed under a three-year grant from the W. K. Kellogg Foundation, and it should prove particularly useful to people interested in changing their careers.

School administrators and

Clearly, a passion for microcomputers is sweeping the halls of academe, from the smallest elementary schools to the largest universities, but this is not to imply that all educators are jumping on the bandwagon or that the computer literacy movement is without its critics. The Ad Hoc Committee on Basic Skills Education, in Palo Alto, California, was established with the express purpose of halting the bandwagon in its tracks. The group's protest focuses on the elementary grades and the notion, as expressed by cofounder Eric Burtis, that "general purpose computers cannot make cost-effective contributions to elementary-level education."

Burtis, it should be pointed out, is President of Centurion Industries, a firm that makes small, single-purpose (or dedicated) computers designed to help elementary school children master various basic skills. They cost less than programmable micros, but can only be used for a single purpose, such as teaching math, as opposed to the micros, which can have thousands of applications.

"It's overkill," Burtis says, "to use a $3,000 computer for teaching reading and arithmetic skills. A recent study conducted by *Instructor* magazine [see p.10] indicated that more than 60 percent of the usage of microcomputers in schools today is directed towards drill and practice. I feel that the products we produce are superior to the general purpose microcomputers for basic drills."

Burtis also claims that his products are available at one-tenth the cost of general purpose microcomputers and have keyboards so simple to use that no computer literacy is necessary.

Many supporters of microcomputers, however, argue that, although they may, at

counselors who would like to learn more about SIGI can request a computer diskette featuring a sample of the program from ETS. They can either use it on a computer at a Radio Shack store or request that Radio Shack lend them a computer. ETS provides SIGI directly to institutions and not to individual users.

"SIGI is humanized software," says SIGI Technical Advisor Susan Wood, "because it is essentially a computer having a discussion with a student about his values, which is something people never thought computers could do. That's the thing that sells SIGI. By the time someone goes to college, he's got an idea of five or six majors. Frequently he'll sit down with a career counselor and spend two or three or four sessions discussing this. Now SIGI goes through the first half of it, and the counselor's time is used more valuably because a lot of the thinking has already been done."

first, sound like a formidable investment, they are, in fact, relatively inexpensive. John Bristol, superintendent of the Lyons Township, Illinois, high school district, argues that its expenditure for 220 microcomputers amounts to only $7.50 per pupil for the next five years.

In his January 1982 *Phi Delta Kappan* article, "Information Technology for U.S. Schools," Arthur S. Melmed, an advisor with the National Institute of Education (NIE), provides a detailed breakdown of the cost, in 1980 dollars, of equipping the nation's schools with enough microcomputers by 1990 so that each elementary and secondary school student could average 30 minutes per day at a computer terminal.

"For about $30 per student per year (including the costs of equipment, maintenance, courseware, and materials other than courseware)," he concludes, "each student in the elementary and secondary education system could enjoy a computer-enriched instructional program averaging 30 minutes a day. This figure represents 1.2 percent of the projected annual instructional budget of $2,500 per student in 1990 (projected by the National Center for Education Statistics). If the cost of equipment were to be provided through a separate (capital) budget, the remaining annual operating cost of $5 would represent only 0.2 percent of the projected annual instructional budget spent for each student. This compares with about 0.8 percent of the instructional budget spent for all instructional materials in 1980."

[illegible]

Beyond its assertion that microcomputers are uneconomical, the Ad Hoc Committee also claims that educators "have no valid proof of the pedagogical value of such technology." A significant amount of research has already been conducted on the effects of computers on education. The results to date are, however, rather mixed and inconclusive. One of the more significant studies, "Issues Related to the Implementation of Computer Technology in Schools: A Cross Sectional Study," conducted by Karen Sheingold of the Bank Street College of Education in New York City, examined the use of microcomputers in schools at three diverse sites only to conclude that little solid evidence was obtainable about their effects on student learning.

"The microcomputer innovation," concludes Sheingold, "is being fueled by a great deal of enthusiasm, with the conviction that the microcomputer is a good thing. Yet, no one knows for sure if it is, how it is, or, really, what it's good for, in terms of educational outcomes. We need to begin acquiring such knowledge very quickly, in order to help guide an innovation which is bound to grow even in the absence of guidance."

Sheingold adds, "What is clear from our study, however, is that microcomputers on their own will not promote any particular outcomes. Their impact will depend, not only on hardware and software, but, to a large extent, on the educational context within which they are embedded."

Another study, conducted by ETS Senior Research Scientist Marlaine Lockheed, working with Antonia Nielson, director of the Computer Center at Princeton High School, examined the gain in computer literacy for students taking a computer science course required as part of the mathematics program at the high school. The study revealed, says Lockheed, that "males, younger students, students in sophomore and junior classes in college-preparatory mathematics, and students in

advanced sections of mathematics gained relatively more than females, older students, and students enrolled in other mathematics courses or section levels.

"Why inequities occur and what is needed to change them are issues remaining to be studied," she adds.

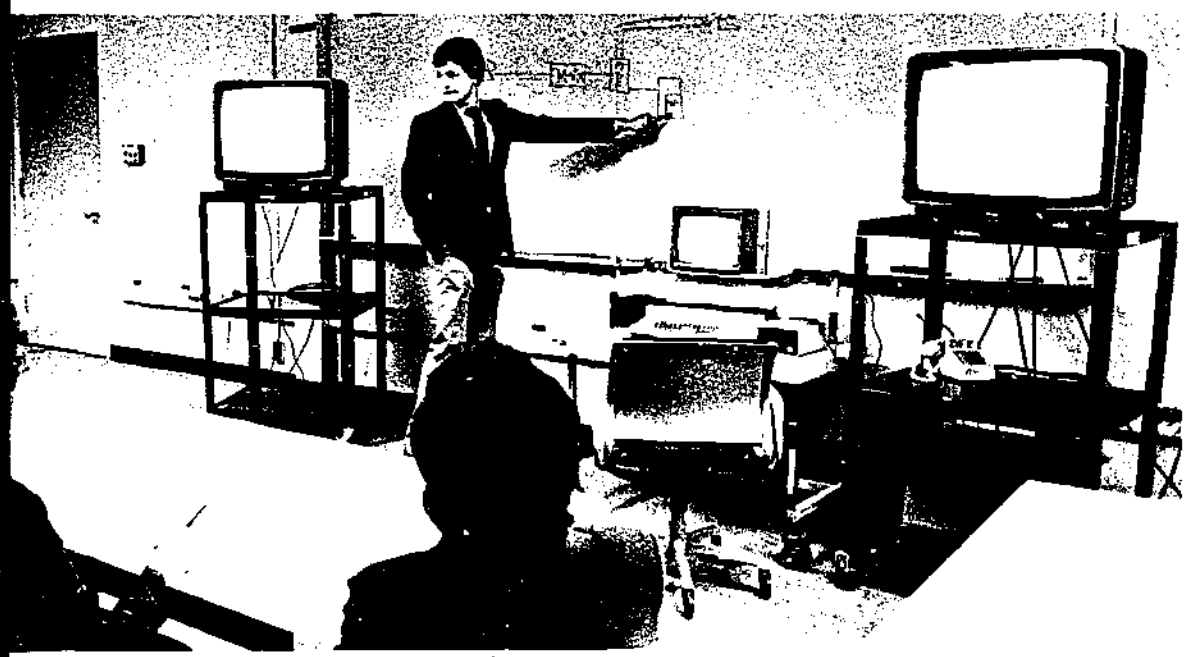
Other studies of the impact of computers upon education have produced more favorable reviews. Many focus on CAI, the most prevalent type of computer education. A four-year longitudinal study of the effectiveness of computer-assisted instruction in remedial education, directed by ETS Research Psychologist Marjorie Ragosta, revealed significant improvement in learning, particularly for those using drill-and-practice programs to sharpen their math skills.

In fact, the study, funded by NIE and conducted at four Los Angeles schools, demonstrated a direct relationship between the amount of time disadvantaged students spent using CAI in mathematics and the improvement of their math skills. According to Ragosta, students spending 10 minutes a day on math CAI showed treatment effects about half the size of those with 20 minutes a day. Some improvement also occurred in reading and language arts, but the results were not so clear-cut.

"Increased amounts of CAI in mathematics, either within the school year or across school years, were associated with higher test scores both on curriculum-specific tests and standardized tests," says Ragosta.

She adds that it was difficult to come up with similarly straightforward results in reading and language arts because the material covered is much more extensive than in math, making it difficult to find external measures that relate as well to the CAI curriculum.

In December 1980 a comprehensive survey of research on the effectiveness of CAI was conducted by the Computer Technology Program of the Northwest Regional Educational Laboratory for the Portland, Oregon, school system. The survey covered studies examining the use of CAI in reading, mathematics, physics, foreign languages, and social studies. Its conclusions were overwhelmingly positive with respect to the effectiveness of CAI as an educational tool. "The data indicate that CAI which supplements traditional instruction is effective in increasing learning by elementary and secondary students. In fact, the weight of evidence is overwhelmingly in favor of CAI. Not only has CAI been shown to contribute to higher student achievement, but there is evidence of positive student acceptance of the use of computers in the classroom.



Although research is sparse, it also appears that CAI can decrease the time required to learn subject matter."

Despite the fact that research generally supports the effectiveness of computer-assisted instruction, many experts remain critical of CAI and suggest that educators would be well advised to look very carefully before they leap into the computer marketplace.

Throughout the literature, inadequate software is cited as the single greatest impediment to the computer revolution. Most manufacturers are content to produce software as inexpensively as possible, and anyone who surveys a representative sample will be struck by how unimaginative and disappointing most of it is.

Much of the available software is full of spelling and typographical errors and bedeviled by bugs that prevent the programs from working properly under certain conditions. Many programs are unusable by children because instructions are unclear and important steps are omitted. Moreover, critics fault existing software for consisting mainly of drill-and-practice and tutorial routines. "Neither of these approaches," writes Kelman in his *Classroom Computer News* article, "taps the protean potential of the computer, nor do they represent a departure from the most traditional of educational methods."

ETS's Martin Schneiderman says that drill-and-practice programs are little more than "electronic workbooks." "We can talk all we want about the creative use of computers," says Schneiderman, "but 95 percent of the software out there is not worth having. Educators should ask whether using a computer merely as a workbook is really a valuable investment for a school district. They should tell the salesmen that they will stick to flashcards and use the computer for more discriminating purposes."

Kelman suggests that the future success of computers in education will depend upon the development of software approaches geared to the unique properties of the computer, such as elaborate simulations and demonstrations, extensive hypothesis testing and variable manipulation, text editing of all sorts, responsive languages like LOGO, and complex educational games.

Perhaps the most judicious and comprehensive examination of the educational impact of microcomputers is Henry Jay Becker's *Microcomputers in the Classroom—Dreams and Realities*, published by the Center for Social Organization of Schools at Johns Hopkins University. The report takes a critical view of many aspects of the computer revolution and comes down on the side of caution, suggesting that schools adopt computer technology only after very careful planning.

The Hopkins report views most schools as not having, or likely to have, enough computers to use them effectively. Moreover, they are being offered hardware and software with limited educational capabilities by sophisticated merchandisers who can easily take advantage of a relatively inexperienced group of customers. The report stresses "the almost complete lack of knowledge about computers by practicing teachers and the likely existence of this deficiency for perhaps another generation."

The Hopkins report examines all the major educational applications of computers and, while pointing out advantages, also finds serious flaws in each one. Drill-and-practice routines, for instance, are characterized as boring and repetitious, much like the workbooks they imitate, and highly questionable in terms of cost-effectiveness.

Even the more innovative simulation and model-building exercises come in for their share of criticism. The report cautions that ". . . research on the learning consequences of simulations has not been uniformly positive. Most studies have found no learning advantages, although student attitudes have shown improvement." Becker points out that very few simulation models can be integrated with current teaching units in various subjects. In fact, much of the educational software, he says, is written in short, disconnected modules unrelated to each other and the curriculum.

The report also questions the notion, promoted by computer advocates, that learning to program develops general problem-solving skills applicable to all areas of the curriculum. Becker says this assumption is not supported by strong empirical evidence, and he cites at least one study demonstrating that programming did not enhance other applications of inferential skill. He also points out that many experts believe most people are incapable of learning how to formulate the precise representations of problems necessary to develop programming skills.

Becker notes, as have others, that relatively few girls are drawn to computer classes, particularly in the high schools. Girls who exclude themselves from these classes in high school may also be excluding themselves from a large share of jobs in the future. The answer might be to use computers in the elementary grades. "If computer programming is introduced before it becomes socially linked with the male gender," Becker suggests, "it is likely to reduce the effect of peer and cultural norms on the sex-distribution of eventual programming skills."

Schools, the report suggests, should carefully develop policies regarding the optimal use of computers and should invest in such equipment only at the point when such educational strategies can be implemented properly. Computer purchases should not precede policy and should not be based upon an emotional response to the pressures of the marketplace.

"I think that the Johns Hopkins report is right on target," says ETS area systems director Roger Kershaw. "People tend to assume that computers are going to be the answer to their problems. You have to know what your problem is before you can say that computers are going to solve it. The software is just not there. I think that schools ought to do an analysis of what's good for them and what price they can afford to pay. They ought to be looking three or four years into the future. To run out and pay for 127 micros would be the wrong thing to do."

Software Evaluation

In districts that have purchased computers, one of the great challenges facing school officials is ferreting out the few nuggets of high-quality software from amidst the garbage. In response to this problem, nearly all magazines dealing with

computers in education regularly provide evaluations of software. These evaluations, however, vary in quality and reliability. Evaluation programs run by independent educational organizations are generally more highly regarded in the field. The Northwest Regional Education Laboratory's MicroSIFT Clearinghouse and the Education Product Information Exchange (EPIE) Institute's software evaluation program are two of the most widely recognized programs for screening and reporting on the quality of educational software.

Located in Portland, Oregon, the MicroSIFT Clearinghouse publishes evaluations of software in its newsletter and also disseminates them through NIE regional exchanges. The evaluations are conducted by teachers throughout the country, and software is judged in terms of its usefulness in fulfilling the curricular objectives for which it was designed. According to MicroSIFT's Donald Holvnagel, opinions are rendered on the basis of 21 different criteria that illuminate the various characteristics of the programs. MicroSIFT is also building a data base at its headquarters that can be searched by interested parties over telephone lines.

"I think that the Johns Hopkins report is right on target."

The EPIE Institute, based in Stony Brook, New York, offers microcomputer profiles to school systems that subscribe to its service. Initially, subscribers receive a set of profiles of all available software, and these are updated twice a year. Software is evaluated by teachers at the grade level for which it is designed, as well as programmers, instructional designers, content experts, and students. They attempt to determine whether the software meets various educational objectives. "We try to determine what it does and does not do," says Jim Dunn, director of the Microcomputer Resource Center at Columbia University's Teachers College and a key member of the EPIE evaluation team. "You make a decision on whether or not it meets your needs."

EPIE's influence will be enhanced by a recent alliance with the Consumer Union. The organizations will jointly provide subscribers with *Pro/Files*, a series of detailed reports on computers, monitors, printers, and software. They will also publish *Microgram*, a monthly newsletter on the microcomputer field. EPIE and the Consumer Union hope to protect educators from inferior merchandise and encourage manufacturers to improve their products.

In order to demonstrate the potential of truly innovative software, ETS Research Scientist Isaac Bejar and former ETSer Spencer Swinton have developed an interactive demonstration laser videodisc that teaches fractions and decimals to fourth- and fifth-grade students. Instead of having to work with routine drill-and-practice exercises, students at computer terminals interact with dramatized sequences on the monitor that are generated by the videodisc. The presentation is light years ahead of the run-of-the-mill workbook exercises illustrated by crude computer graphics.

Swinton calls the videodisc "the most interactive visual piece of material ever designed. You can take this same video and use it over again for other exercises. By using overlays, we can develop graphs with scales, arrows, and text. All you need is a videodisc player and a computer to get it into the classroom."

Swinton says the system will be demonstrated at conventions and other meetings of educators in order to influence publishers to begin manufacturing first-rate

software and to encourage educators to refuse to settle for second-rate products.

Inservice Training

Beyond inadequate software, schools must cope with the fact that most teachers have not been trained to use classroom computers and, in fact, often know less about computers than do some of their students. John Lipkin, in the November 1, 1982, *Education Times*, says that "over 90 percent of the nation's teachers lack the skills or training for effective microcomputer instruction." The National Center for Education Statistics reports only 27 percent of those now teaching computer courses are highly trained.

David Moursand, professor of computer science at the University of Oregon, estimates that only five percent of the approximately 1,350 teacher-training programs in the country offer undergraduate courses in computer education and that only a fraction of those require such courses for a degree. Moursand suggests that all teacher candidates be required to be computer literate before graduating and that school districts make knowledge of computers a criterion for employment.

The potential impact of teachers' colleges, however, is limited because the vast majority of teachers who will be in the classroom during the next decade are already there. Little hiring is being done in most parts of the country.

Therefore, if computers are going to be used productively in the classroom, ambitious graduate and inservice training programs must be developed. Many teachers' colleges already provide summer courses for teachers who wish to learn how to use computers in the classroom, and some, such as Arizona State, Columbia University's Teachers College, Lehigh University, the Ontario Institute for Studies in Education, Stanford, and the University of Oregon, offer graduate degrees in computer education.

In Minnesota, MECC has successfully implemented intensive inservice training programs throughout the state to prepare teachers for using computers in the classroom. Minnesota's coordinated statewide effort, however, is so far unique.

Individual school districts designing computer literacy programs would be well advised to follow the Lyons Township strategy of providing inservice training to the entire faculty before instituting the curriculum, so that teachers in all fields will be able to make use of the machines in their courses. This is particularly important if computers are not to become the special province of the math department, as has happened at some schools.

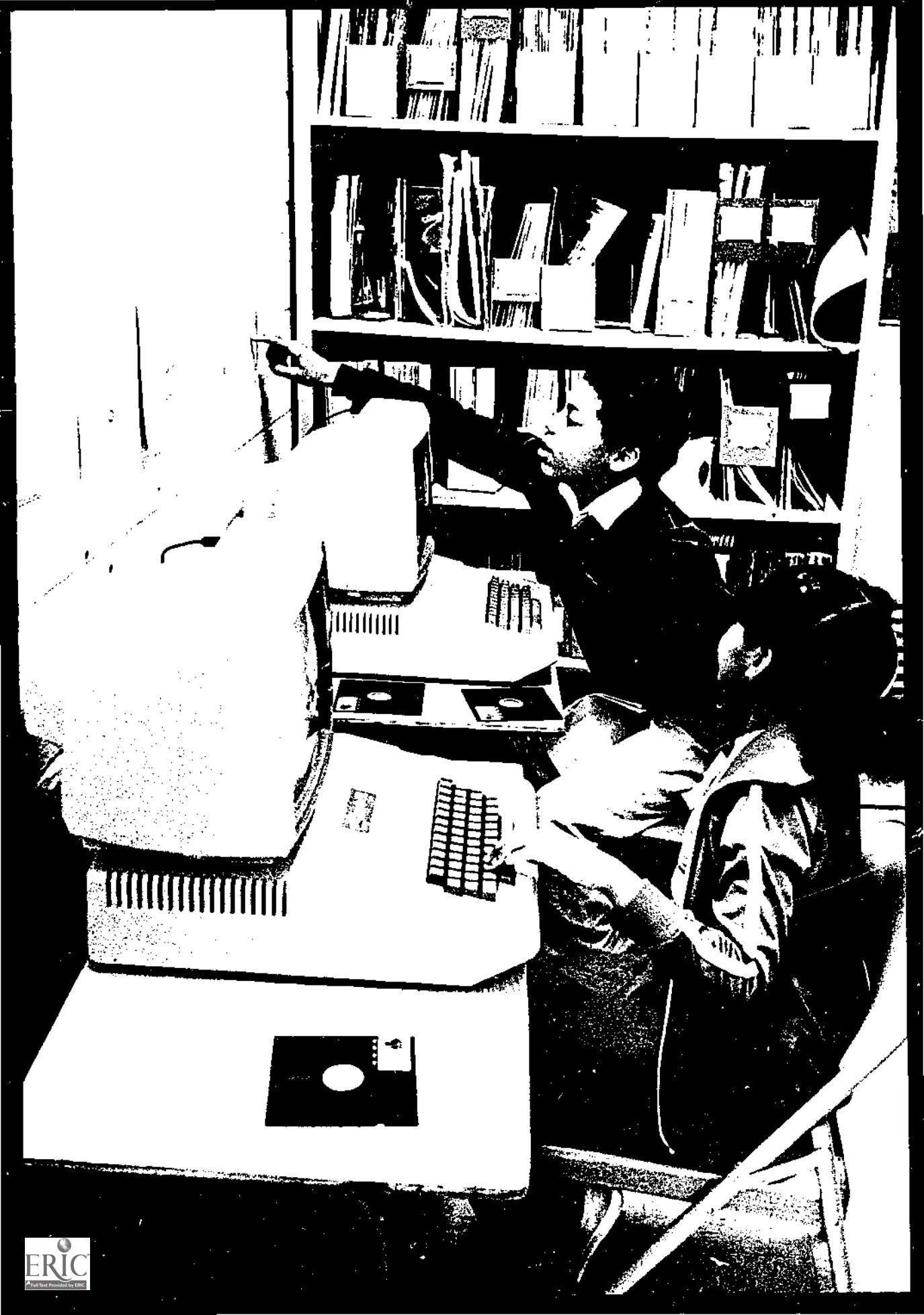
Many organizations, ranging from colleges and universities to corporations, now provide inservice training programs for teachers. ETS sponsors a series of workshops for teachers and administrators covering various aspects of computer education (see next page).

THE IMPACT ON EDUCATION

Inservice training can prepare teachers to use computers creatively and effectively in the classroom. But nothing currently on the horizon seems likely to prepare them for the profound changes in the structure and content of education that some experts see as emerging from the computer revolution.

In the Gallup report, "The Digital Generation," Robert Bezilla raises a number of questions concerning the impact of computers on the curriculum. "How does one grade a student composition that has been automatically edited and checked for spelling?" he asks. "How can emerging literary, art, and music forms be facilitated? What will be the impact of undergraduate access to vast retrieval networks for bibliographic research and entry to original data bases? What becomes of the traditional lecture room and seminar format once asynchronous, nongeographically dependent electronic networks become available for use by students and their mentors?"

Some educators have argued that the advent of the computer age will make some basic skills now emphasized in the schools obsolete while elevating new and somewhat different skills to a level of fundamental importance. For instance, some are predicting that computers will radically alter the kind of mathematics



As attention to the educational applications of microcomputers continues to grow, administrators and teachers at every educational level are attempting to decide whether their schools should invest in the technology. Few educators, however, are experts in the field, and most are barely knowledgeable.

ETS, therefore, has developed a series of seminars for elementary and secondary educators that provide them with the knowledge and skills necessary to become critical consumers of computer-based systems and to use computers effectively in the classroom. The presentations include lectures and discussions as well as the opportunity to sample hardware and software provided by various manufacturers.

"We've kept the size of the groups at a level where everybody can have an opportunity to get experience using the computers and to encourage the kind of interaction so important to the seminars," says Martin Schneiderman, who develops and runs the seminars.

The seminars, covering a variety of topics and geared to audiences with differing degrees of expertise, are held throughout the year in ETS's new Technology

Lab. The lab is equipped with hardware and software representing almost every major manufacturer.

"Our philosophy is that people can find out about computers, but they're often finding out from people with a vested interest in their purchase. People come to us because we have a lot of expertise in recent computer technology and we have a number of interesting research projects on microcomputers. We provide them with accurate, up-to-date information about how to use computers and really have no vested interest if they do or don't do it. That puts us in a very valuable position as far as the schools are concerned."

The 1982-83 seminars are listed below.

Introduction to Computers

An introductory session that provides educators with a nonthreatening experience with computers. This one-day seminar covers the fundamentals of computing, including a short history of computers, the major components of computers and their operation, the capabilities and limitations of computers, computer terminology, and sources of information about educational computing. Participants also get hands-on experience with a variety of computers and courseware and perform a basic programming exercise with Big Trak, a computerized tank.

Implementing Microcomputer Programs: A Seminar for Decision Makers

This two-day seminar provides decision makers with the knowledge and skills necessary to implement instructional or computer literacy programs. Participants learn how to assess the instructional computing needs of a school or district, identify barriers and incentives to success, develop action plans, develop curriculum, conduct staff training, select courseware and hardware, develop budgets, and specify base requirements.

Designing and Implementing Computer Literacy Programs

This one-day seminar for curriculum coordinators and teachers focuses on the principal aspects of introducing computer literacy programs at the elementary and secondary levels. Using a case study approach, participants develop a model curriculum and implementation strategies. They learn how to develop goals and objectives and how to select instructional materials.

Selecting and Evaluating Instructional Courseware

This one-day seminar is designed for educators interested in learning how to select and evaluate microcomputer instructional courseware. They learn how to identify sources of courseware and how to conduct in-depth courseware evaluations, focusing on both technical and pedagogical effectiveness. A variety of evaluation techniques and instruments are used.

Administrative Applications of Microcomputers

This two-day seminar provides school and business administrators with an understanding of the capabilities and limitations of the microcomputer as an administrative tool. Participants are able to use microcomputers to solve a variety of administrative problems. Computer applications covered include data base management; word processing; financial modeling; graphics; library applications; and test-item creation, banking, and scoring. Hardware and software selection are covered, as are methods of making the transition to computerized administration.

taught at even the lowest grades.

"As part of this trend," says Harold G. Shane, in his *Kappan* article, "educators are forced to question the necessity of routine math drill when $10 calculators can instantly compute percentages and square roots. I suspect that tomorrow's schools will deemphasize the *mechanics* of ciphering but place more stress on pupils' acquiring a greater understanding of the *meaning* of numbers, including how to recognize reasonable solutions or answers to math problems fed to the calculator.

"The intellectual payoffs of a knowledge of computing," he writes, "may be as great as the vocational ones. To work with a computer a person has to express his/her ideas in the form of a computer program. The program, then, is a new representation of one's thoughts, in the same sense that a mathematical equation or a paragraph in English is a representation of one's ideas. People who can use computers this way have a new way to think about problems and to solve them. In this sense, computer problem solving is a new basic skill—basic, because it can be applied to many other specialized topics."

Other educators have predicted that the learning of facts will become far less important in the educational process because vast quantities of information will be readily accessible through computer networks. Students will merely be taught

how to gain access to this material.

"The 'Information Explosion,'" writes psychologist Herbert Simon, "has changed the meaning of the verb 'to know': in the past 'to know' meant 'to have stored in one's memory,' but today knowing shifts from having actual possession of information to the process of having access to it."

Because less time will have to be devoted to the learning of facts, optimists suggest that teachers will be able to concentrate more heavily on developing their students' cognitive and analytical skills. They argue that it will be necessary to redesign the curriculum, at every level, in order to take advantage of this opportunity.

Implications for Public Education

There are those who warn, however, that the very structure of American education will soon become outmoded if public schools and colleges cannot move swiftly enough to train people for the computer age. High schools, which offer relatively low salaries compared to industry, are unable to hire or retain sufficient numbers of teachers with expertise in computer science. Similarly, high corporate salaries are attracting students away from Ph.D. programs in computer science, so that universities are unable to find anywhere near enough instructors to teach the hordes of students interested in entering the field. The January 14, 1983, *Wall Street*

Journal reports that, in 1982, only 50,000 graduates were available to fill 115,000 computer-related jobs.

ETS Vice President Anastasio says, "I think that society and technology may pass the schools by. As a result, we will see the private sector get more involved in education. ITT, Control Data, and Bell & Howell already own chains of trade schools. In addition to making money, they can train people to do the things that they need to have done.

"These people aren't being trained adequately by the public sector. They aren't being trained as well as the companies would like by higher education. So they'll do it themselves. Let's just say a student has a strong interest in computers. Someone says to him, 'You can get your degree from the ITT Technical Institute. They won't charge you too much for it. And while you're getting it, they will train

you to do the following things.' Lots of people might find that very attractive.

"In 10 years," cautions Anastasio, "many people may find it more attractive to get their degrees from AT&T. or Bell Labs. or IBM. And the degrees won't all be in systems engineering or computer design. I think they'll start there and just expand.

"Basically, that suggests we might wind up with three broad segments in our society. Some people who will continue to be educated at the top private and public universities, independent of what happens in the private sector. Another group who will get very good training and occupational and professional degrees largely or wholly supported by the private sector. The third segment, and perhaps the largest in terms of numbers of people, are the people who are not going to get trained in computer literacy and who are not going to have an opportunity to break into or have an impact on what goes on in computer technology and related fields. I think that's unfortunate. I don't know how to change it, and I'm resigned to the possibility that the education establishment in our society is not sufficiently well organized—and has no hope of being sufficiently well organized—to change it. We can go along with it, influence it a little bit, but we can't drive it.

"What we need are formal programs of instruction and training to develop computer literacy skills, not just one or two computers in each school. If you really want to make some progress, you have to have a curriculum, you have to have a structure for administering it, and you have to have people to supervise it and deliver it. While I see some steps in the right direction, I'm not convinced that the changes will happen soon enough. We don't have the people to teach computer literacy, we don't have the funds to train the people to teach it, and we don't have the funds to put the equipment in the schools.

"That doesn't mean there aren't schools all over the place that are in one way or another fighting to change things, but they're on the periphery, the fringe. I think, from the point of view of state reform or national reform, it's just not going to happen."

The educational system has proved resilient in the face of other challenges, but it is clearly at another crossroad now. Anastasio argues that computers are more than just another new educational tool: they have the power to reshape the very structure of American education. The decisions made in the next few years about the nature and importance of computer literacy programs in the schools may well determine whether the schools themselves will survive in their present form.

GLOSSARY

ALGORITHM: An orderly step-by-step procedure, like a recipe, that consists of a list of instructions for accomplishing a desired result, or for solving a problem. In computer programming, an algorithm is expressed as a flowchart.

BASIC: A high-level computer language widely used in small computers. An acronym for Beginners All-purpose Symbolic Instruction Code, this language was developed at Dartmouth University. Terms used in BASIC are English-like, and the language was designed for interactive use.

BUG: A bug is a malfunction either in a program or in hardware. Software bugs usually result from a logical error in the creation of a program.

COMPUTER-ASSISTED INSTRUCTION: Direct instruction conducted by the computer.

COMPUTER-BASED INSTRUCTION: The overall term used to describe the use of computers in the instructional process.

COURSEWARE: A combination of subject matter content, instructional design, teacher and student materials, and the software that causes a computer to implement instructions.

DEBUG: Process of finding, locating, and correcting errors in a program that might create problems or provide inaccurate information.

DISK (DISC): A magnetic medium for the storage of computer-readable information, i.e., bits. Shaped like a phonograph record, the magnetic disk allows very rapid access to information stored at any location on the disk.

DISK DRIVE: The electromechanical system that holds the disk while it is being read or written on by the computer.

FLOPPY DISK: A disk made of a flexible, magnetic medium and contained in a cardboard envelope, usually black. This disk spins at approximately 300 r.p.m. in its envelope and is read through an access hole by a reading head in contact with the disk.

FLOWCHARTING: A programming technique using shaped blocks to indicate the sequence of operations in a program.

GRAPHICS: Characters that can be used to create figures, shapes, and forms on the monitor.

HARD DISK: A disk made of a hard, ceramic-like material used for auxiliary storage.

HARDWARE: The physical parts of a computer system as opposed to software—for example, the central processing unit, printers, and disk drives.

LANGUAGE: The set of instructions understood by the computer.

MEMORY: The component of a computer system that retains information.

MICROCOMPUTER: A small computer, usually based on a microprocessor. There is no hard and fast definition for a microcomputer as opposed to a minicomputer. In broadest terms, a computer costing less than $20,000 is probably a microcomputer.

MICROPROCESSOR: Developed in the late 1960s at both Intel Corporation and Texas Instruments, the microprocessor is a silicon chip containing the fundamental elements of a computer.

MONITOR: A specially designed cathode ray tube for use with a computer.

PASCAL: A high-level computer language that gained favor rapidly in the late 1970s for small computers. Pascal is generally preferred to BASIC for writing large programs because it encourages segmentation of programs into small, understandable pieces.

PROGRAM: A series of instructions to a computer that cause it to solve a problem or perform a task.

SOFTWARE: The programs that guide or direct a computer system. A set of operating instructions, procedures, and programs that direct the computer system to perform the desired task.

TERMINAL: A peripheral device, usually combining a keyboard and cathode ray tube, that facilitates human communication with a computer.

WORD PROCESSING: The use of a computer to produce documents.

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