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ABSTRACT

In four chapters, this research report on computers in education examines computer hardware (the machinery) and software (or courseware, programmed instructions that tell the hardware what to do), classroom uses of computers, ways of bringing computers into the schools, and four districts that have successfully introduced computers into their schools. Chapter 1 discusses microcomputers, centrally located "mainframe" computers, and speech synthesizers. Educational courseware described includes such programs as drill and practice, simulation, tutorial, and problem-solving. Chapter 2 explains the two most significant applications of computers in schools: computer-assisted instruction (CAI) programs, which provide students a one-to-one learning environment, immediate attention, and feedback geared to abilities; and computer-managed instruction (CMI) programs, which enable teachers to monitor students' progress, diagnose problems, prescribe remedies, produce reports, and analyze curriculum effectiveness. The contributions of CAI and CMI to individualized instruction are also noted. Useful practical information for bringing computers into the classroom is considered in the next chapter, including implementation of computer literacy programs to overcome "computerphobia," evaluating and purchasing hardware and software, and integrating computers into the existing curriculum. Case studies from Illinois, Florida, Texas, and California are presented in the final chapter. (PB)

# Administrator's Guide to Computers in the Classroom



Clearinghouse on Educational Management
College of Education · University of Oregon

# Administrator's Guide to Computers in the Classroom

John Lindelow

ERIC

Clearinghouse on Educational Management
College of Education
University of Oregon
Eugene, Oregon
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## FOREWORD

The ERIC Clearinghouse on Educational Management is pleased to add this report to the School Management Digest, a series designed to offer educational leaders essential information on a wide range of critical concerns in education.

At a time when decisions in education must be made on the basis of increasingly complex information, the Digest provides school administrators with concise, readable analyses of the most important trends in schools today. The goal of this analysis is improvement of educational practice. Each Digest points up the practical implications of major research findings so that its readers might better grasp and apply knowledge useful for the operation of the schools.

The author of this report, John Lindelow, was commissioned by the Clearinghouse as a research analyst and writer. We deeply appreciate his skill in organizing and bringing clarity to the large amount of information on the topic.

Philip K. Piele
*Professor and Director*

Donna Allison, a fourth-grade teacher at Jefferson Elementary School, is working at her desk after school, reviewing her students' progress and formulating lesson plans for the next day. On the microcomputer in front of her, she punches in the name of each student, and the screen responds with an array of information on that student's performance on a variety of achievement tests. With the push of another key, the results of several personality and developmental tests appear.

Donna reviews each student's records every day, for each day there are new data. The microcomputers that the students work with for up to two hours every day frequently test the students in a variety of ways. To the students, these tests, along with most of the learning material presented, are often too enjoyable to be considered "work." Students usually interact with the colorful screens for significant periods without losing interest.

Today, Donna's attention is focused on one particular set of records—those belonging to one of her "problem" students, Wally Roberts. The graphs of Wally's performance in most subject areas show that he is indeed slowly learning, but in an erratic, up-and-down fashion. In mathematics, however, Wally's records show steady improvement and a moderately high level of achievement.

These results puzzle Donna, and she changes the screen to view the elements of Wally's learning style. Wally's learning style profile shows such features as a strong preference for auditory perception; cognitive processes characterized by field dependence, a low tolerance for incongruous experiences, and a need for a slow conceptual tempo; affective processes characterized by high curiosity, an exterior locus of control, and a low frustration tolerance; and physiological preferences for low light, an informal learning environment, and working in the afternoon.

Donna has been modifying Wally's instructional program in light of this learning style data. She has modified Sally's instructional environment and her own teaching strategies and has made special modifications to the computer programs that determine the patterns of interactions Wally has with the computer. Yet he does not seem to be responding.

Perhaps, she thinks, there is something new in the research literature that may help her. In seconds, Donna connects her microcomputer to a computer database on education. Within a short time, she has located three recent articles that outline instructional strategies for students with learning styles like Wally's.

A science fiction fantasy? Perhaps. A number of advances in instructional science and computer technology, however, promise to make such scenes commonplace realities in the short-term future.

Educators, though, should not be misled: what is critical in the above scenario is not simply the use of computers in the classroom. Rather, the important difference is in what this new technology is making possible on a large scale: individualized instruction. Through the use of computer technology combined with our continually advancing understanding of the learning process, truly individualized instruction is being transformed from a far-off dream to an attainable goal for the classroom of the eighties.

This digest focuses on the technological advances that are fast bringing the goal of individualized instruction within the grasp of the public schools. The first chapter describes the current state of the art in both computer hardware and in the all-important "software" that directs the raw computing power of IBMs and Apples into educationally-useful channels.

The second chapter describes the two most far-reaching applications of computers in the schools: using the computer for the management of individual learning programs, and using the computer for instruction itself. This chapter also discusses the probable state of instructional delivery in the late 1980s and beyond, when computer-assisted and computer-managed instruction are combined with "learning styles" research.

The next chapter contains practical information for getting from "here to tomorrow." The first roadblock administrators usually meet in introducing computers into their schools is "computerphobia"—an irrational fear of computers and their workings that is rarely seen in children but is extremely common among teachers and administrators. The first section of this chapter characterizes computerphobia and describes its primary antidote, namely computer "literacy."

Many administrators—convinced of the importance of computers in the schools—have purchased hardware and software without careful thought, only to find that the new machines don't "work" for their purposes or have other shortcomings that make them troublesome to use. Much of this wheelspinning can be prevented by following the guidelines for hardware and software purchase outlined in the second section of chapter 3.

Good hardware and software in themselves, though, are not enough. The long-range impact of computers on education depends in large part on how their use is integrated into the existing curriculum. This important topic is the subject of the last section of chapter 3.

The final chapter describes how several districts and schools have successfully introduced computers into their educational programs. As many educators will attest, nothing helps so much when doing something new and important as seeing how others have done it.

CHAPTER 1

# THE COMPUTER REVOLUTION IN EDUCATION

From the vantage point of the future, the present era may *not* be known, after all, as the nuclear age or the space age. Instead, it will likely be named after a technology that has already made a far more profound impact on society than have nuclear power plants or space shuttles. This "computer age" is still in its embryonic stages, but its pervasive influence is already apparent in many sectors of society. When combined with advances in communications and information science, say many modern soothsayers, the computer will restructure society as completely as the steam engine did in a former age—and public education will not be spared.

The latest phase of the computer age began in the late 1970s with the introduction of "microcomputers"—low-priced, stand-alone devices capable of performing essentially the same functions as larger "mainframe" computers, though at a slower pace. Numerous educators and computer scientists predict that these new microcomputers will revolutionize the delivery of education within this decade.

Many seasoned educators, though, are unmoved by these prophecies—and for good reasons. They have heard before the overblown claims that this or that technology—radio, film, TV, teaching machines, or programmed instruction—will "transform" public education. Moreover, since the early 1960s educators "have been listening patiently to the transistorized tales of future educational rapture spun out by computer buffs," as W. James Popham attests.

So will the revolution in education actually materialize this time? Or is it possible that public education will again escape unscathed from the ravages of the latest technological advance?

The present evidence strongly suggests that the computer revolution will indeed have a forceful impact on public education in the 1980s. Moreover, the influence of this revolution will likely be felt in the schools whether or not educators take steps to prepare for its coming: the coming tidal wave of technological change, many observers predict, will easily wash over the traditional political levies that have protected the public schools from the tides of societal change in the past.

If this sounds farfetched, consider the reasoning of Stanley Pogrow, who recently completed an extensive study of the policy implications of technological change for the School Finance Project of the National Institute of Education: "History suggests that a technology will play a central role in the public schools if—and when—it first gains cultural acceptance (i.e., admittance to a large number of homes) and becomes a primary work tool," says Pogrow. "The first factor reduces opposition to the introduction of a particular technology into the schools; the second factor generates public demand that the schools adopt the technology and provide training in its use."

These two criteria will be met by the mid-1980s, Pogrow continues, when 10 percent of all U.S. households will have microcomputers and when 25 percent of all jobs will utilize microcomputers as the primary work tool.

The technological relevance of the curriculum, then, will be the busing issue of the Eighties—the issue whose outcome will determine whether the public schools can retain the children of the middle class." If the public schools do not heed demands for technological relevance, they could become victims of what Pogrow calls "environmental collapse"—a condition in which dissatisfied constituents and clients abandon an organization for an economically compelling alternative, instead of trying to provoke the organization to change. In this case, the compelling alternative would be private schools with technologically relevant curricula and tuition made affordable through tuition tax credits or educational vouchers.

The hard reality, Pogrow concludes, is that the public schools "will never achieve technological relevance, or even maintain the existing curriculum, without first rejecting the traditional bromides and developing totally new management approaches"—approaches that focus on the integration of computers into the classroom. The failure to devise and implement such new approaches could lead directly to the "environmental collapse" of the public schools.

The educational administrator interested in keeping the public schools "relevant" to the technological times, then, would be advised to keep abreast of the rapid developments in computer technology and of projections for the future of computers in education. The information presented in this chapter and the next will help meet this need by giving educators a "snapshot" view of the computer revolution in education. It must be emphasized, though, that even a year or two from this writing—sometime in 1984 or 1985—this picture may be only a blurred image of educational reality. The reader is thus advised to keep in close touch with the literature and developments in the field of educational technology.

The first subject discussed in this chapter is the widely heralded revolution in computer "hardware." Hardware, as the name implies, refers to all the parts of the computer system that are, well, "hard," that is, the actual machine. "Software," on the other hand, refers to the programmed instructions that tell the hardware what to do. Software usually exists in the form of magnetic tapes or "floppy discs" on which the programmed instructions are encoded. A special kind of software that is used to tell computers how to teach is called "courseware." Courseware—which is the real key to the use of computers in education—is the next topic of discussion.

## HARDWARE

Of the many terms used to describe the amazing development of computer hardware, "exponential" is the most apt. Every year since 1960, says Patricia Sturdivant, the number of electronic components that can be placed on a single silicon microprocessor chip has doubled. In 1979, ten thousand words—the size of a daily newspaper—could be stored on a chip and any part accessed in one-one thousandth of a second or less. In the early 1980s, whole encyclopedias can be stored in the same space. Recent developments in "bubble memory" promise even more mind-boggling compressions of information.

Dramatically increasing capabilities are only one part of the computer development story, however. At the same time capabilities are soaring, both size and cost are plummeting. For example, the central processing units of the latest computers are now so small you can barely see them. Just twelve years ago, an equivalent processor would have filled a room.

As with hand-held calculators, which plunged in cost from several hundred dollars to under ten in less than a decade, the cost of computers has fallen precipitously. A version of a computer that would have cost $25,000 a decade ago costs less than $1,000 now, says Sturdivant, and this includes a keyboard, cathode ray tube, floppy disc capability, and cassette player.

In the short-term future, says Christopher Evans, computers will continue to become both cheaper and "quite dramatically smaller," while their reliabilities and memory capacities will dramatically increase. Price decreases will result from mass production of microprocessor chips, intense competition among microprocessors as the huge home and educational markets open up, and the decreased requirements for raw materials and energy supplies as the integrated circuits continue to shrink.

One result of these continuing trends, says Sturdivant, is that cost has already been removed "as the primary obstacle to widespread use of computers for instruction." Now, schools are buying computers for instruction at a rapid pace. According to *Educational Technology* magazine ("TECHnically Speaking . . ." October 1981), "the schools are *rushing* to implement computer technology in the classroom."

Recent statistics support this view. According to a telephone survey of all 15,442 U.S. school districts conducted between July and September 1981 by Market Data Retrieval of Westport, Connecticut, nearly 16,000 of the nation's 84,000 public schools (19 percent) utilized computers for instruction. An identical survey in July-September 1982 showed that 25,000 schools, or 30 percent, were using computers. *Conservative* observers predict that over 40,000 schools (50 percent) will have at least one computer by fall 1983, and that by 1985, 85 to 90 percent of the nation's schools will be utilizing computers for instructional purposes.

"When one reflects on the fact that there were no microcomputers in existence in the world until about 1975, and no full-scale national marketing of these products until about 1978," states *Educational Technology* ("Computer News . . ." December 1981), "the numbers reported [in these surveys] must be seen as truly remarkable and possibly without precedent in the history of education—a field generally thought to be virtually impervious to rapid diffusion of change and innovation."

What is even more remarkable is that schools are purchasing microcomputers despite extremely tight budgets and declining enrollments. Apparently, many educators have already accepted the inevitability of the coming "computer society" and are buying computers to keep their curricula "technologically relevant," as Pogrow has insisted is necessary.

So microcomputers are entering the schools, and rapidly at that. But will computers continue their invasion of the schools as the eighties progress? There are several good reasons to think so. First, as mentioned earlier, the cost of microcomputers is still shrinking while the raw abilities of these machines grow by leaps and bounds every year. The end of the "exponential" of computer development is not yet in sight; thus, microcomputers will become increasingly affordable and able as the eighties unfold.

Second, the entire society is being influenced by the computer revolution. Computers are already familiar objects in businesses and offices and are rapidly entering the home arena as well. Computers will enter the schools through public demand for relevant curricula or through "osmosis" from the rest of society, if not through administrative action.

Third, the quality of educational software available will improve steadily. Schools and districts will establish quality educational programs using computer-assisted instruction (CAI) as a key element. CAI will free the classroom teacher to give individualized attention to students who need it and to concentrate on the "creative" aspects of teaching. Going back to the traditional method of teaching will become inconceivable. Computers will become—or will seem to become—indispensable to a good educational program. Echoing the business managers of today, future educators will wonder how they ever got along *without* computers.

The discussion above has focused on the entry of microcomputers into the schools. The microcomputer, however, is not the only type of computer being used for educational purposes. Many districts are using or experimenting with another type of educational computer system that uses a large, centrally located "mainframe" computer.

The most advanced of these mainframe systems is the PLATO system, which was developed in the late sixties and early seventies by the Control Data Corporation and the University of Illinois. PLATO is a time-share system, in which classroom terminals are connected to a large central computer; it utilizes touch-sensitive screens with advanced graphics capabilities.

"A considerable amount of courseware has been developed for PLATO," Lou Frenzel reports, "and today it is probably the most successful CAI project in existence." According to Michael Levin-Epstein, over seven thousand hours of course material are now available. PLATO is "quite efficient, some excellent courses are available, students *learn* using PLATO and, in general, express positive feelings about using it," says Gerald T. Gleason.

The main problem with PLATO is its cost, which is prohibitive for most school districts. A single terminal currently costs around $9,000 per year. Yet some educators and computer industry executives are confident that time-share systems will grow and prosper in the years to come, particularly if combined with microcomputers in flexible networks.

Before leaving the discussion of computer hardware, it is worth noting one additional piece of technology that could have a significant influence on education in the eighties—the speech synthesizer. "What this new auditory component will do for the acceptance of CAI and CAT (Computer Aided Testing)," says Richard P. Cummins, "in my opinion will be the rough equivalent of what the 'talkies' did for the nascent movie industry in the early 1930's."

Speech synthesizer hardware and programs are already being marketed. When more fully developed, this technology will further broaden the scope of computer applications in education. Computers will be capable of teaching reading to students with no prior reading ability. They will also be able to teach other subjects without the prerequisite of reading ability. Visually handicapped students will, of course, benefit greatly.

Further down the road is the development of speech recognition devices that will allow a computer to understand human speech. Already, some computers can "understand" a few simple spoken commands.

Many futurists predict the development in the not-too-distant future of computers that can carry on dynamic conversations with their users. Combined with the continuous ultraminiaturization of computer components, these developments may give rise to knowledgeable and talkative computers the size of calculators, or even wrist watches.

Granted, this may be down the road a way. But such devices will be created if current trends persist. The value of these forecasts here is to give educators an idea of what may lie beyond the eighties. Even before the eighties are over, however, computers will likely be talking fluently to their users, and some will be able to interpret human speech.

## COURSEWARE

> If using computers to teach has a future, then good courseware products are the building blocks for that future.
>
> M. D. Robyler (January 1982)

A classic cliché of the computer field concisely sums up the importance of good computer programs: "Garbage in, garbage out." No matter how sophisticated or capable a piece of computer hardware, the quality of its output will be determined directly by the quality of its input—whether that input is data of some sort or the instructions that tell the computer what to do.

The capabilities of computer hardware have risen exponentially, as discussed earlier. But the exploitation of the potentials of that hardware lags far behind, traveling a much more modest developmental course. As hardware development proceeds by leaps and bounds, the hiatus between computer capabilities and the exploitation of those capabilities widens. Only long after the limits of hardware development have been reached (as they inevitably will be, though they are not yet in sight) will the plodding development of software finally catch up.

Given this state of affairs, it is not surprising that the number one problem facing computer-based education today is the lack of quality courseware. As discussed earlier, the foremost problem *used* to be the cost of computer hardware. Quality hardware, though, is now in plentiful and affordable supply. That leaves the development of quality courseware as the only technical stumbling block left between today's approach to educational delivery and tomorrow's computerized classroom.

This is not to imply, however, that good courseware does not already exist. Most of the PLATO system's courseware is generally considered to be excellent, for instance, while many good courseware programs exist for microcomputers as well.

Currently existing courseware is of several different types. By far the most common is that utilizing a "drill and practice" format, in which the computer quizzes the student on some concept or body of information. Usually, drill and practice programs are designed as supplements to classroom instruction: the classroom teacher is expected to introduce the concept, then the computer provides practice and feedback to reinforce the learning of the concept.

Another common type of program uses simulation to teach students about "real time" situations. A simulation program, according to a report by the Educational Products Information Exchange (EPIE) Institute, allows students to manipulate "a model of some object system" and "become part of that simulated reality." Simulation programs have already found wide use for training in industry and the military, but the potential of these programs for public education is only beginning to be tapped. Besides their use for teaching many common concepts, simulation programs can be used as money-saving surrogates for science laboratory experiments.

Some educational programs are designed as games: they present situations in which students have to know certain facts or master certain skills or concepts in order to "win." These programs—with their electronic game parlor appeal—are generally very motivating for students; apparently education doesn't *have* to be boring to be good.

Educators, says Frank J. Clement, would do well to gain an understanding of "what it is that will keep people entranced by computerized games for hours at a time. Very often they are developing complex skills of planning and strategy that instructional designers would find difficult to emulate by traditional methods."

Some existing programs use what is called a "tutorial" approach. The computer explains or illustrates concepts for the student, carries on a dialog with the student, evaluates the student's understanding of the concept, and provides feedback and remedial help as needed. Tutorials are intended as "stand-alone" programs that do not generally require concept introduction by a teacher. Many of the PLATO system's courseware programs use such a tutorial approach.

A fifth type of courseware asks students to find the solution to novel problems. These "problem-solving" programs, says the EPIE report, should be carefully distinguished from those that ask students to routinely substitute "numerical values in mathematical expressions of the same type—a kind of 'drill'." Problem-solving programs involve "the combining of previously learned rules into a new higher-order rule, which 'solves' the problem and generalizes to an entire class of stimulus situations embodying other problems of the same type."

A sixth type of courseware could be called "exploratory." Such programs require that students synthesize "many problem-solving skills into one creative endeavor," according to the EPIE report. Instead of being "programmed by the computer," as, for example a drill and practice type program would do, the student is encouraged to think independently, using the computer as a tool.

These categories of courseware, it should be stressed, are by no means cut and dried. Individual programs frequently use several different approaches, or other approaches that do not fit neatly into the above typology. Courseware programs, in short, can be designed to be as flexible and diversified in approach as a creative classroom teacher.

One example of a good-quality drill and practice type program is the "Critical Reading" (CR) program reviewed by Randall L. Gull and John C. Alluisi in *Educational Technology*, September 1981. According to the reviewers, CR "is one of the best written courseware packages currently available."

The CR program is designed to teach four logical rules of inference dealing with "or" elimination, "all" elimination, conditional statements, and inductive reasoning. A prerequisite for using the program is a third-grade level reading ability.

The reviewers describe the working of the program as follows:

> The starting point for work in an instructional unit is the pretest, which tests the student's competence using the particular logical rule. Based on the pretest performance, the student is assigned an appropriate instructional lesson. The lessons, which number two or three per skill level, provide practice in the use of the rule. Items missed by the student the first time through the lesson are recycled up to two times.
>
> Following each lesson, a progress check is administered. The progress check, which tests the student's understanding of the lesson material, can cause the student to skip, advance, or retake a lesson. As reinforcement, the progress check allows the student to improve upon his or her score by recycling problems answered incorrectly. The initial score is recorded and determines the student's placement in the unit.
>
> At the end of each lesson series, the student must take a posttest. Structurally similar to the pretest, the posttest serves well as a learning "barometer." By comparing pretest scores with posttest scores, the instructor is able to determine whether or not the students benefited from the lesson series material.

Sounds simple enough, doesn't it? Yet it is surprising how much time and knowledge it takes to put together a quality program of this sort. It is equally surprising how many ways such a program can be botched, and how many poor quality courseware programs are marketed and sold. The reason CR is a cut above the others, say the reviewers, is that it was "designed and written based on pedagogically sound strategies supported by documented instructional research." Most courseware is *not* designed in this way, at least not yet.

There are signs, however, that courseware developers are beginning to learn just what it takes to design a good teaching program. First, developing good courseware demands a special blend of expertise. As M. D. Robyler (January

1982) states, "courseware is not only instruction, with all of the instructional design variables which must be addressed in creating effective learning materials, it is also a computer program." Thus, what is usually needed is a team of specialists including an instructional designer, a content specialist, and a computer programmer.

Second, creating good courseware demands extensive evaluation to determine instructional effectiveness and extensive "debugging" to remove the numerous small errors that can make an otherwise excellent program very frustrating to use. Needless to say, evaluation and debugging are expensive propositions. When commercial courseware developers compare the option of marketing excellent but expensive courseware with the option of marketing poorly planned but cheap programs, they often choose the latter. The only function this serves, usually, is to keep the manufacturer in business awhile longer. The purchasers of such courseware receive little benefit from it and probably become disillusioned about using computers for instruction.

In the years to come, says Robyler (March 1982), courseware development "will continue to be a time-consuming, labor-intensive activity." One hour of good courseware, in fact, still takes "100-200 person hours or more, depending on the experience of the development team and the nature of the product." Estimates vary widely, says Gleason, but $10,000 for one hour of high quality courseware is not excessive. Among the necessary activities that add to this expense are "careful specification of objectives, selection of programming strategies, detailed analysis of content structure and sequence, development of pretests and posttests, preliminary drafts, revisions, trials, validation, and documentation."

There is good reason, though, why developing quality courseware is worth this price. A good courseware program is like having a teacher in a bottle, or, in this case, on a floppy disc. It is permanent, can be copied and distributed widely, and can be used to teach again and again in a dynamic and interactive fashion. One quality hour-long program could conceivably be used to teach millions of students, say, the basics of trigonometry. Good courseware thus is a good investment of educational dollars.

What does the future hold for courseware development? Currently, courseware is in an embryonic stage of development. A hodgepodge of programs is available, and the chaff of the programs is far more plentiful than the grain. As the eighties progress, however, available courseware will grow more plentiful and sophisticated. Hundreds of new and old firms are just now entering the courseware market. Many districts are developing their own courseware, some of which is now available through software exchanges and clearinghouses.

In the next few years, commercial courseware developers and the publishing giants in education will begin offering extensive, integrated courseware programs. The PLATO system already has thousands of hours of programming, and some limited educational systems are already being marketed for microcomputers. Individual districts will develop their own computer-based educational programs, utilizing a mix of commercially developed and district-developed materials.

As the science of instructional design progresses, courseware will become increasingly sophisticated. Computers will begin to interact with students just as knowledgeable and infinitely patient human teachers would. Courseware will be designed that will continuously monitor both student performance and learning style variables and then will adjust instructional strategy and level of difficulty to meet the needs of the student.

In sum, all signs are positive for the continued development of computer courseware in the eighties. The road will not be completely smooth, and some hard lessons will still need to be learned. By the end of the decade, though, the importance of computer courseware to a school system's total instructional program will have increased dramatically.

CHAPTER 2

# USING COMPUTERS IN THE CLASSROOM

Computers and their programs can be used to perform numerous different tasks in the schools. Norman Watts discusses an even dozen of these uses, including applications to administration, curriculum planning, research, guidance and special services, testing, library services, professional development, and teaching computer literacy and computer science. (These and other uses are further detailed in a recent Educational Research Services report titled *School District Uses of Computer Techology.*)

The two applications that have the greatest potential for altering the actual delivery of education, however, are the use of the computer for instruction and the use of the computer for the management of the instructional process. Computer-assisted instruction (CAI) and computer-managed instruction (CMI), then, are the topics of this chapter. A final section describes the probable state of educational delivery in the late 1980s.

## COMPUTER-ASSISTED INSTRUCTION

> The fear of dehumanization through computers appears to be dissipating in direct proportion to the amount of contact individuals have with computers. It appears that most students prefer attention from the machine rather than neglect from overworked teachers. The computer is simply a tool that relieves teachers' tasks and helps them individualize instruction. The new instructional techniques and materials offered by technology may actually free teachers from constant drill and review, giving them time for personalized attention to students and for course expansion and enrichment.
>
> Joy Senter

The thought of using a computer to teach seems to strike a cold nerve in many administrators and teachers. Yet it is clear, as Senter states, that the computer is indeed "simply a tool" and as such can be used to implement any educational philosophy, whether it be humanistic, authoritarian, or any shade between.

Many educators also still doubt the ability of computers to be of any help in the educational process. Reinforced by vague memories of the "teaching machines" of the fifties and sixties collecting dust in the school's basement, these educators look on microcomputers as just the latest in a series of technological gimmicks.

Educators' feelings of fear and skepticism of classroom computers, though, seem to melt when they are exposed to the workings of a good computer-assisted instruction (CAI) program, in which the hardware and software discussed in the last chapter are combined and put to use. The students seem so interested and motivated and are really learning the material presented. The teacher has a new assistant and can devote more time to the creative aspects of teaching and to the individualization of instruction. Once familiarity with the new machine is gained, initiates to the world of CAI often start tallying the advantages of computerized classrooms instead of dwelling on possible shortcomings. In short order, it becomes obvious that CAI holds great promise for the improvement of the educational process.

Most of the advantages of CAI stem from the fact that the classroom computer—when appropriately programmed—can perform many of the teaching tasks that the teacher normally performs. Thus the computer acts as a de facto teacher's aide. For example, the teacher may introduce and explain new concepts and then have the students work with a particular computer program to reinforce those concepts. The computer might present exercises and illustrations, ask students to respond to questions about a concept, correct misunderstandings with immediate feedback, and then measure each student's mastery of the concept.

The computer as teacher's assistant not only saves the teacher's time and supplements his or her lessons, it also teaches in an individualized and nonthreatening manner (if programmed to do so, of course). Each time a student works alone with a computer, it is like being in a tutor-tutee relationship. As Brother Austin David and Robert L. Williams note, the learning environment with CAI is "one-on-one," a "feature that many would hold to be a hallmark of excellent instruction." The individual student receives immediate attention and feedback, so the "moment of need" is not blunted or lost by "classroom queuing." The presentation is geared to the level and pace of the student, and, if so programmed, the computer can adjust the instructional approach to the learning style and learning needs of the student. Finally, the computer can perform all these actions in an infinitely patient, unbiased, and nonthreatening fashion and can continually give positive reinforcement to learners. Try finding a teacher's aid with all these traits!

Currently, computers are conceived and used in the classroom strictly as teaching aids-as the term "computer-assisted instruction" implies. As courseware develops in sophistication in the later 1980s, however, computers will become capable of taking over more and more of the classroom teacher's traditional duties. Computers will progress from drill-and-practice type duties to higher level teaching activities such as teaching concepts or problem-solving skills. As the eighties progress, teaching computers will start acting more and more like the human teachers they are modeled after.

## COMPUTER-MANAGED INSTRUCTION

Back in the fifties and sixties, only the largest companies used—or could afford to use—computers for management purposes. As computers decreased in size and expense, smaller and smaller companies and management units began to utilize computers. Today, it is common to find small businesses everywhere using microcomputers to manage records, inventories, and other information necessary for successful management. For companies of all sizes, computers have become indispensable management tools.

A parallel development is occurring in the public schools. Many districts have used computers in the management process for years. Some individual schools also utilize computers for recordkeeping, energy management, word processing, and other purposes. But it is still rare to find computers being used at the classroom level for the management of the instructional process. By the late 1980s, though, computer-managed instruction, or CMI, could become the norm in most of the nation's schools.

The initial motivation behind the idea of CMI, according to Donald N. McIsaac and Frank B. Baker, was "the need to satisfy a high demand for accountability." With the rise of the accountability movement, schools were increasingly required to justify their actions regarding individual student learning programs, and CMI was one response. Many users of CMI, though, recognized that CMI could lead directly to better education by providing timely and appropriate information for educational decision-makers.

Early attempts to use CMI were troublesome propositions because they were carried out on time-shared systems with remote job entry terminals in the schools. Although technically feasible, such systems are expensive and procedurally cumbersome, and they do not give users direct control over the computer.

The microcomputer, however, has changed all this, say McIsaac and Baker. These authors describe one CMI program called MICRO-CMI, which is now being used in the McFarland (Wisconsin) Public Schools. This system is probably the state of the art of CMI today.

Every student in each McFarland elementary school has an "Individual Performance Profile" report in the school's computer, which provides information on that student's progress. The MICRO-CMI system also has a "program of studies" function that "enables the recording of a specific program for each individual student." This function is particularly useful in special education, where individualized educational plans (IEPs) are required for all students.

The MICRO-CMI program also has a "diagnosis and prescription" capability. The objectives of the curriculum are entered into the system and then are "keyed to objective-based tests with prescribed levels of mastery." After grades are entered for a student, the computer prepares a "prescription" based on the student's performance. The teachers decide beforehand what these prescriptions should be and program the computer accordingly. Prescriptions are forwarded to the students.

A particularly promising feature of the MICRO-CMI system is its "grouping functions," which "give the user the opportunity to dynamically form and reform groups of students for the purposes of instruction." In the McFarland schools, students in reading, math, and science are instructionally regrouped every two weeks in accordance with their specific educational needs. According to McIsaac and Baker,

> Such instructional grouping is extremely difficult to accomplish without a computer. Regrouping 200 students in reading required five teachers and about ten hours of time (50 hours in all). The computer produces a far more complete grouping recommendation in less than one hour.

The result of the frequent regroupings is that students "experience an instructional program tailored to the individual student. Students work on tasks for which they are ready, teachers devote more time to the teaching task, and the computer provides both with information.

Besides the above functions, the MICRO-CMI system also performs some of the more mundane classroom chores. Tests can be scored with an appropriate scanner, lists and reports of many sorts can be produced, and student records are automatically updated.

The best news about MICRO-CMI, however, is its cost. McIsaac and Baker estimate that for a population of 700 students, the system would cost $25,000 for a five-year period ($15,000 acquisition cost plus $2,000 per year for operation). An equivalent time-sharing system would cost about $100,000 for a five-year period.

If systems such as MICRO-CMI are available now, what lies further ahead in the eighties? To begin with, one can expect CMI systems to get better and cost less as the decade unfolds. These developments, in turn, will lead to the much wider use of CMI systems in the nation's schools.

McIsaac and Baker suggest the next inevitable step: the merger of CAI and CMI. Students' work on instructional computers will be monitored by a central CMI computer. Classroom teachers will be able to monitor student progress, diagnose problems, prescribe remedial programs, produce reports, and analyze curriculum effectiveness using the CMI terminal on their desk top. The CMI computer will automatically monitor the performance of students working at instructional computers and will put a wide variety of important information at the finger tips of the classroom teacher.

## INSTRUCTIONAL DELIVERY IN THE EIGHTIES AND BEYOND

> We have long known, from the wise elders of Greece and Rome to the contemporary British tutorial system, that instruction tailored to fit the learner works well, maybe even best. Such instruction was until now only available to the elite. I think we can do better: we now have the wherewithal to provide such learning for all those who desire it. Michael J. Cosky

The individualization of instruction has been a consistent goal of public education for many decades. Yet it has remained an elusive and largely unattained dream.

Many attempts have been made to alter classroom practice so that teachers can give individual students more personal attention. These efforts have some success, but both common sense and experienced teachers will confirm that providing truly individualized programs for twenty-five students is an impossible task with today's technology. Lowering the student/teacher ratio is one possible approach, but in the present political and economic climate there is little chance that public education will receive increased funding.

Cost, then, remains the primary obstacle to individualized instruction. A secondary obstacle is our present level of understanding of the learning process; even if educators had the resources to do so, would they know how to best provide an individualized educational program that would be of maximum benefit to each student? Today's educators are trained in the art and science of group instruction, with all its inherent shortcomings. The science of individualized instruction, though, is another ballgame.

It is possible, though, that the advancements in technology discussed above, combined with advances in the science of instruction, may provide the "wherewithal" Cosky mentions by removing the obstacles of cost and lack of understanding that have long prevented the attainment of individualized instruction for all students. In fact, advances on the two fronts may act synergistically to make individualized instruction the norm in public schools in the eighties or early nineties.

Advances in technology may advance the science of instruction in the following way: when large numbers of students are working regularly at computers, great amounts of data on learning style, response patterns, curriculum effectiveness, and so forth can be collected automatically by the computer, without the expense and inconvenience of classroom observers. Moreover, the data will be collected by completely objective and continually attentive observers whose methods are completely standardized. The net result of CAI for educational researchers, then, will be an incredible increase in the amount and quality of data available for analysis. This deluge of date should lead to a better science of instruction.

If, indeed, a better science of instruction results from the new data, it can be applied to improve the instructional process, whether computerized or not. In particular, educational software and courseware design will benefit from the advances in pedagogical theory that classroom computers will help stimulate. In this circular fashion, advances on one front may stimulate advances on the other, and educational technology and instructional science may advance rapidly, hand in hand.

Already, researchers and educators are talking about bridging the world of computer technology with the emerging science of instruction. Cocky, for example, discusses the use of learning style data to individualize the delivery of CAI. See also *The Emerging Science of Individualized Instruction: A Survey of Findings on Learning Styles, Brain Research, and Learning Time with Implications for Administrative Action*, published by the ERIC Clearinghouse on Educational Management in the School Management Digest series.

Most courseware programs already adjust their delivery to the pace of the learner. Many also have different levels or "tracks" of presentation for learners with different levels of knowledge and competency. Switching to a higher or lower track occurs when a student understands or fails to understand the first level of presentation. Courseware is also "individualized," as any instructional material is, according to the entry-level knowledge required to use it and the proficiency level of learning it transmits to the learner.

But there are few if any programs available today that monitor aspects of student learning style (other than pace and level of delivery) and then adjust their "mode" of delivery accordingly. There are many reasons for this, one being the still disorganized state of the learning style field. In the years to come, though, many more programs will become available that will monitor many characteristics of the learner (through responses to questions, performance in gamelike activities, pattern of keyboard response, and even tone of voice) and then adjust the delivery of instruction to the learner's preferred mode.

Some students, it should be noted, do not respond well to CAI, no matter what quality or kind of program is used. CAI itself, then, has certain learning style requirements, as William H. Pritchard, Jr. discusses. Students must have a certain amount of manual dexterity at the keyboard, for example, and a willingness to sit still. CAI probably works best with students who are visually dominant, who prefer working alone, and who have strong intuitive and diagnostic abilities.

Continuing technological advances—such as miniaturization and the development of computers that can talk and hear—will solve some but not all of these incompatibility problems. Future courseware that adjusts to other aspects of learning style will help other students who now have difficulty working with computers. Even those students for which CAI does not click, though, should benefit from the extra teacher time that CAI will make available for individualization.

One optimistic administrator who is obviously sold on the computer revolution is George Young, superintendent of the Saint Paul (Minnesota) Public Schools. His view of the future of educational delivery combines many of the ideas discussed above and makes a fitting conclusion to this chapter:

> Computer systems are capable of freeing teachers from much of the burden of presenting subject matter to students, thus providing time for teachers to discuss the meaning, significance, and relevance of subject matter, and to work with individuals to assist

them in comprehending the concepts to which they have been exposed.

This technology can keep track of each student's learning, determine the best teaching strategies for each student, and direct teachers to those materials available in the total inventory of the school which best fit each student's learning style.

An individual educational program can be constructed for each student on a daily basis which takes into account all that is needed to know to make that program the best one for that student for that day.

This kind of electronics technology, if used, will permit a school to be organized to fully utilize its human resources to monitor the learning of each student, to diagnose the problems which prevent the student from learning, to make judgments about what should happen to solve those problems, and thereby to make certain that no student in the schools is "lost."

CHAPTER 3

# GUIDELINES FOR BRINGING COMPUTERS INTO THE SCHOOLS

> While a great many people were still debating whether or not the horse would ever be replaced, society's leaders failed to plan properly for the impact that the technology of the car would have on our civilization. The proper question . . . now . . . is not whether (a microcomputer revolution) is coming, but how to handle it when it does come.
>
> Dustin Heuston, quoted by Roblyer (1981)

As was stressed earlier, the public schools have little chance of escaping the effects of the computer revolution. The "information age" is upon us, and it is causing the very structure of society to rearrange itself. This great societal metamorphosis promises to transform even the public schools.

Some administrators will be prone to defend the status quo as these changes take place. What the public schools need today, though, are active and insightful *managers of change* who will help build the world of tomorrow instead of resisting its inevitable coming. A new kind of society is emerging at our feet, and today's educators have a golden opportunity to help determine its form. The public schools *can* be a vital and necessary part of tomorrow's world, but they won't just drift into place; they must be guided by administrators with vision and purpose.

Many administrators have already acknowledged these developments and are now actively preparing their schools for the world of tomorrow. Among the practical concerns they are addressing are those described in this chapter: implementing computer literacy programs (both students and teachers), overcoming "computerphobia," purchasing hardware and software, and integrating computers into the existing instructional program.

## COMPUTER LITERACY AND COMPUTERPHOBIA

Among the skills that all educational systems attempt to transfer are those of reading, writing, and mathematics, commonly referred to today as the basics. These skills are essential to every literate society and will likely remain so well into the future. The computer revolution will however, add one important communication skill—that of computer literacy. Computer literacy can be defined as skill in the use and programming of computers combined with knowledge of computer applications and the societal issues surrounding computer use.

We now live, says Andres R. Molnar, in an "information society" brought on, in large part, by advances in electronics, communications, and information technology. "Information has become a national commodity and a national resource and has altered the very nature of work." If individuals are not computer literate, they will be unable to meaningfully participate in actions that affect their lives." Thus, as computers become prevalent in homes and businesses throughout the nation, teaching computer literacy will come to be seen as a fundamental responsiblity of the public schools.

Teaching computer literacy need not be an expensive undertaking, as Dorothy J. Stevens points out. One microcomputer per five hundred students, in fact, is probably adequate if the goal is to teach minimal computer literacy skills. "Once computers are omnipresent in school environments," says Stevens, "the pressures involved in training large numbers of students for computer literacy will wane. Only entering classes will require training; other groups of students can enhance their computer knowledge commensurate with interests and goals."

The first step administrators should take to make their schools computer literate is to make sure they themselves are computer literate. "Those educators who are the key instructional leaders," says Richard S. Lavine, "should be given extensive training designed not only to increase their knowledge of computers, but to provide the necessary skills to impart this knowledge to other members of their instructional staffs." Lavine suggests that administrators—particularly principals—seek such training from local universities or colleges.

The next step is to teach the instructional staff to be computer literate. Many teacher training institutes are realizing that computer literacy has become an essential topic for preservice education. For those teachers already in the classroom, however, inservice programs must be implemented.

Antonio M. Lopez, Jr. describes a computer literacy program for teachers that consists of ten hours of lecture combined with "countless hours of lab work with microcomputers after school hours." The first lecture session is an introduction to microcomputer hardware, the second introduces programming, the third explains CAI, the fourth teaches how to write basic drill and practice programs, and the fifth covers program modifications.

This literacy program was conducted in two Louisiana schools, Lopez reports, with very encouraging results. Teachers learned a great deal about computers and computer programming and thus "became better prepared to assess the feasibility of a potential educational application and, perhaps to develop it themselves." The teachers also "seemed to lose their fears and anxieties about dealing with computers."

A more cautious approach to exposing teachers to computers has recently been described by Helen C. Lee. "Plot your course deliberately but project a low profile," she advises principals. When the school's first microcomputer is delivered, install it in the outer office and "make a point of being seen at its keyboard." Offer to demonstrate the computer to passing students and teachers.

Allow the "computer-wise" teachers to come forth and borrow the microcomputer for their classrooms. In a week, move the micro into the teacher's lounge along with a few educational games. "Once the microcomputer is in the teachers' lounge," says Lee, "an interesting phenomenon takes place. It becomes *their* machine. Those who avoided it in your outer office now take note of the hardware and software, pause at the console, and make eye-to-eye contact with the screen."

Interest in the computer and its abilities will now be mounting. Principals should set out periodicals and books on educational computing and try to obtain and photocopy articles that will answer teachers' questions.

The next step should be inservice training. Lee suggests that a steering committee of teachers be created to determine the kind of training teachers desire. Next a consultant specializing in educational computing should be hired. The consultant should be neither a "wiz-bang expert in educational gimmickry" nor a "messiah who brings panaceas." Instead, the consultant should be adept at introducing teachers to computers in an understanding manner and should deal directly with the attitudes and myths that produce computerphobia.

The computer should be put on a cart initially for easy transportation between classes. Teachers should be encouraged to take the micro home overnight or over the weekend. Finally, says Lee, a variety of good software should be carefully purchased so that all teachers can use the computer for instruction.

"Once exposed to using computers in their classrooms," state Lee Marvin Joiner, Sidney R. Miller, and Burton J. Silverstein, "teachers tend to become interested in developing skills so they can develop their own student-oriented courseware." And when teachers become involved in developing courseware, they often gain an increased sensitivity "to the organization of information and the learning process."

The final step in making a school "computer literate" is to introduce students to computers and their applications. Numerous computer literacy programs are now on the market, many of which are reviewed in *Educational Technology* and similar journals as they become available. A district or school may, of course, choose to develop its own computer literacy program. This would be an easy process if the administrators and teachers are already computer literate.

One promising computer literacy program is now operating in the Fairfax County (Virginia) Public Schools. According to Richard S. Lavine, a principal in this district, the program has four major components: K-6 computer literacy, intermediate computer literacy, Computer Science I and II at the high school level, and an advanced computer applications course. The key to the program, says Lavine, is the computer applications course, because "the most advanced students at each high school can write the software and courseware necessary to update and upgrade the intermediate and elementary programs." This approach makes the program "self perpetuating" and also solves the problem of acquiring and updating expensive software.

Teaching administrators, teachers, and students to be computer literate is the best remedy for an ailment that is common in the public schools these days: "computerphobia." The symptoms of computerphobia, says Timothy B. Jay, include

- a fear of physically touching a computer;
- a feeling that one could break or damage the computer or somehow ruin what is inside;
- a failure to engage in reading or conversation about the computer, a type of denial that the computer really exists;
- feeling threatened, especially by students, and others who *do* know something about computers;
- an expression of attitudes that are negative about computers and technology, for example: (a) feeling that you can be replaced by a machine, (b) feeling dehumanized, or (c) feeling aggressive toward computers (let's bend, fold, and mutilate these cards!). Such feelings are indicative of an underlying feeling of insecurity and lack of control; and
- a type of role reversal, whereby the person assumes the role of slave to technology rather than the master of a fine tool.

The best cure for computerphobia is exposure to and understanding of computers. Individuals can overcome their fears by beginning a course of personal education on computers. More promising are organizational approaches to teaching computer literacy, as described above.

## EVALUATING AND PURCHASING COMPUTER HARDWARE

If you are convinced that computers can improve your school's instructional program and want to acquire computer hardware as quickly as possible, stop right where you are.

A "bandwagon" mentality is definitely present in the educational computer business that tends to numb the higher reasoning centers of even experienced administrators. Add to this the pressure from a half-dozen computer salesmen and the ground has been laid for a modern-day "sting."

This is not to imply, however, that using microcomputers in the schools is just another passing fad. All evidence indicates that today's computers can be valuable instructional tools and that they are here to stay.

What is needed more than anything during this confusing transitional period is clear and calm thinking on the part of those who are ushering in the new technology. Before purchasing any kind of computer hardware, then, administrators should carefully think through and validate their plans for using computers in their schools. The investment now of a small amount of time and energy to make a wise choice of hardware can prevent big headaches later.

As *Educational Technology's* April 1981 issue ("TECHnically Speaking. . .") notes, "it has been typical of schools for generations that they will purchase hardware and other 'solutions' to problems without at first determining the nature of the *problems* that they would like to have solved." The first step in breaking this habit is for the schools to conduct needs assessments before purchasing any computer hardware.

A useful guide for conducting a needs assessment prior to hardware purchase is provided by Shirley Douglas and Gary Neights in *Microcomputer Reference: A Guide to Microcomputers*. The first tool provided by these authors is a three-page checklist of projected school uses for microcomputers. This checklist help administrators get a more realistic idea about possible uses of computers in the schools.

Next, the authors provide "tally" and "comment" forms for the evaluation of individual computers. Seventeen criteria, including costs, flexibility, keyboard layout, music generation, servicing, and user training, are explained and listed with spaces for comments, "importance factors," and "criteria rankings." Importance factors are determined with the help of the use projection form. Criteria rankings indicate how a particular computer rates on the criterion in question. A total score for each computer is calculated by multiplying each criterion's importance factor and rank and then adding.

Douglas and Neights also provide other helpful information for making a hardware purchase, including a nine-page glossary of computer terms, an elemental discussion of how computers work, and a list of organizations and consortia involved in educational computing.

The Northwest Regional Educational Laboratory, in *Microcomputers in Today's Schools: An Administrators' Handbook*, also discusses the process of acquiring computer facilities, including the all-important steps of justifying the procurement of computers and conducting a needs assessment. Advice on acquisition is proffered according to the experience and knowledge levels of the responsible administrator, whether low, medium, or high.

This useful handbook also reviews recent research on CAI and discusses such topics as the management applications of microcomputers, the usefulness of computers for teaching basic skills, and the state of the art in using computers to teach the handicapped. Also provided are profiles of eight schools or school districts in the Northwest that are successfully operating CAI programs.

Lavine has outlined a few specific criteria for hardware purchase. First, the random-accessible memory (RAM) of the computer should be readily expandable, even if you need only a small amount of RAM now. "Any microcomputer you purchase should be easily expandable to *forty-eight thousand bytes of RAM*," says Lavine. Second, a variety of peripheral devices should be available for the computer, such as floppy disc drive units, printers, and interface equipment that allow "fast retrieval of data, written records and future network capability."

Third, the computer should have a good reliability record. When maintenance is needed, it should be readily available with a turnaround time of less than forty-eight hours for most repairing. If repairs are to take longer, a replacement unit should be available.

Finally, a variety of quality software and courseware should be available for the computer. Most major microcomputer manufacturers use slightly different versions of a computer language called BASIC. Unfortunately, these programs are *not* interchangeable. "Thus," says Lavine, "your microcomputer is tied to the software written for its version of

BASIC."

This last criterion cannot be overstressed, because it is the lack of available courseware that most often causes microcomputers to be "shelved." A case in point is the IBM Personal Computer, a microcomputer introduced in fall 1981. Although the hardware is considered excellent by knowledgeable reviewers, there is currently a paucity of educational software for the IBM. A school or district purchasing the IBM would have to develop its own courseware (an expensive and complex task, as the next section will discuss) or wait until appropriate courseware becomes available on the market. Many schools have enthusiastically purchased other brands of microcomputers, only to find them of little use because of a lack of software.

Arthur H. Bell suggests additional criteria for the purchase of computer hardware. The purchaser should ask whether the dealer provides training without cost, whether a lease with buy-out provision is available, and whether discounts are offered to educators and institutions. Bell also suggests the commonsense—but often overlooked—practices of talking to current users of the computer under question and spending a few hours reading consumer information on the brands in question. Several consumer guides to microcomputers are available (see Tony Webster, for example), and reviews of hardware and software are published regularly in *Educational Technology* and similar journals.

## LOCATING AND EVALUATING SOFTWARE

Ten years ago, the most formidable barrier to the widespread use of CAI was the cost of computer hardware. Since the advent of the microcomputer revolution, though, the availability and quality of educational software has become the new number one problem facing CAI. This section acquaints readers with the most important sources of courseware and software and describes tools for evaluating software once it is found.

Microcomputer software and courseware are available from many sources. The most obvious source, one would think, would be the manufacturers of computer hardware.

But life is not this simple. Microcomputer manufacturers specialize in making hardware, and only a few have attempted to develop much educational software for their own machines. Of course, these companies realize that most (but not all) educators will buy their machines unless software is available. So some, according to Patricia Sturdivant, have secured software from other developers, by contract or through royalty agreements.

The primary sources of educational software today, as mentioned previously, are the commercial software development companies. These firms will continue to supply most software for the next few years, but by the late eighties, the publishing giants of the educational world will take a large share of this market. After a long wait to see if the educational market would develop, these large educational publishers recently started developing their own software offerings. In a recent article, M. Sokoloff briefly reviews the growing volume of educational software offered by Houghton Mifflin, McGraw-Hill, Milliken, SRA, Random House, and Scholastic.

Another new source of quality microcomputer-based educational software, as mentioned earlier, is the control Data Corporation, makers of the PLATO time-share system. Control Data has just begun to convert its massive (7,000 hour) library of instructional software for use on micros. In the near future, the new PLATO packages may well become standards of microcomputer courseware design.

A final source of software is individual school districts and even individual educators. Much of this software is developed for a specific school's or district's curriculum, but it may still be of use to others.

How, though, can software from these sources be located? Aside from contacting known software producers directly, interested educators can consult four basic sources: direct advertising in magazines and journals, software exchanges and user's clubs, clearinghouses on educational software, and software directories and sourcebooks.

Commercially produced software is regularly advertised, listed, and sometimes reviewed in such journals as *Technological Horizons in Education (T.H.E. Journal)*, *Media and Methods*, *The Computing Teacher*, and *Educational Technology*. (See Addendum to Bibliography for addresses.)

An example of an educational software exchange is "SOFTSWAP," established by the San Mateo County (California) Office of Education and the organization of Computer Using Educators (CUE) for the purpose of distributing educational software as widely as possible. In March 1983, SOFTSWAP offered approximately 430 public-domain instructional programs collected for the TRS-80, Commodore PET, Apple, Atari, and Compucolor microcomputers, according to the San Mateo County Office of Education. Some programs are now being translated for use on the IBM and Texas Instruments microcomputers. All these programs have been evaluated and edited for errors by educators and may be ordered by mail for a nominal fee of $10 per disc. (There are about sixty-five discs total, with several programs on each. For a $1.00 catalog write to San Mateo County Office of Education, 333 Main Street, Redwood City, California 94063.)

"MicroSIFT" is the name of the nation's primary clearinghouse for microcomputer-based educational materials at the elementary and secondary levels. MicroSIFT (Microcomputer Software and Information for Teachers), established by the Northwest Regional Educational Laboratory (NWREL) in Portland (Oregon) disseminates information about microcomputer-based software at the K-12 levels, develops and implements courseware evaluation models, and develops guidelines for the development of new computer-based instructional materials.

NWREL has also established a computer database that contains information on the current "state of the art in the application of computers in schools," according to a recent newsletter. This database, called RICE (Resources in Computer Education), contains information on commercial and noncommercial producers of instructional and administrative software, and descriptions and evaluative information about known software packages. Complete data from software evaluations conducted by MicroSIFT are included, along with bibliographic references to other sources of evaluative date.

The information in the RICE database is stored on the computers of the Bibliographic Retrieval Services (BRS) and can be accessed much as the ERIC (Educational Resources Information Center) database is now accessed. The NWREL anticipates that most acces to RICE will be by "organizations such as intermediate education units and state education agencies" that provide computer database search services for their constituent districts or schools. RICE can also be accessed through any library or other center that provides searches using the BRS system. Complete details on becoming a subscriber to RICE can be obtained by contacting the NWREL at 300 S.W. Sixth Avenue, Portland, Oregon 97204 (503-248-6800).

A number of available software directories can direct interested parties to both independently developed software and software published by commercial firms. For example, the biannual *School Microware Reviews* (see Dresden Associates) is designed to provide information on "the operation and quality of pre-college instructional software sold for use on microcomputers," according to Paul F. Merrill. Radio Shack has published an "Educational Software Sourcebook" that lists software designed for its TRS-80 microcomputer. Other computer manufacturers have published similar directories.

Some of these directories also evaluate the software they list. The first issue of *School Microware Reviews*, for example, describes and fully evaluates fifty microcomputer programs available for use on the Apple II, Commodore PET, and Radio Shack TRS-80. In the future, this publication's "User Software Review Program" will provide the bulk of evaluative input. This initial issue also indexes the reviews of nearly three hundred additonal microcomputer programs to the journals in which they are reviewed. According to the compilers, this is the most comprehensive such index published to date.

Another directory, written by Denyse Forman, Stuart Crawford, and Ross Tennant, contains evaluations of courseware programs for the Apple II from sixty-three different manufacturers and distributors. The reviews, ranging from one paragraph to numerous pages, include information on programming language used, peripherals needed for operation, memory requirements, grade level of programs, documentation included with the program, and quality of instructional content. This voluminous directory, weighing in at 873 pages, also includes an annotated index of more than seven hundred instructional software programs currently available for the Apple and reproductions of courseware catalogs from dozens of manufacturers.

But what about teachers and administrators interested in evaluating their own courseware, or courseware not yet evaluated by others? For these do-it-yourself educators, the Northwest Regional Educational Laboratory has published an *Evaluator's Guide for Microcomputer-Based Instructional Packages*. This guide has already been widely used and "debugged" by the network of large school districts and regional consortia that evaluate courseware for "MicroSIFT," the laboratory's clearinghouse for educational software.

The first step in the evaluative process outlined in this guide is to acquire some factual data about the courseware. Descriptive information needed includes grade or ability level, required hardware, required software not included in the package, instructional objectives and prerequisites, user's role, instructional strategy, and program structure.

Sample forms are provided for both the courseware description and for the second step in the process—the actual evaluation. Twenty-one items for evaluation are listed and thoroughly explained. Items include the accuracy of the content; its educational value and freedom from social, ethnic, or sexual stereotypes; whether feedback from the learner is used effectively; how much control of rate and sequence the learner has; how comprehensible and effective the user support materials are; and how easily the instruction can be integrated with previous student experience. Overall, this guide can be an excellent resource for educators interested in independently evaluating microcomputer courseware.

One school system's approach to selecting computer software has recently been explained by Donald Dearborn, an assistant superintendent in the Alexandria (Virginia) City Public Schools. The Alexandria school system has established a "Computer Technology Council" consisting of central office and school personnel. The council reviews computer hardware and recommends appropriate purchases; reviews and recommends courseware for remedial, regular, advanced, and special education programs; and "develops and/or purchases computer programs for courses that can no longer be offered due to enrollment decline."

To provide uniform evaluation of software, the council developed a four-part software evaluation form, which Dearborn includes. The software evaluator first reviews the program's documentation—its teacher's guide or manual—and then completes the first part of the form. The second part records the evaluator's impression of how "the software correlates with the school system's documented curriculum," which Dearborn considers the most important criterion for software selection.

In the third part, the evaluator examines the actual quality. Finally, in the fourth part, the evaluator comments on the program and recommends that the district purchase—or not purchase—the program. Using the standard form for software evaluation is important because it provides for constancy of evaluation. It is also important, says Dearborn, to have more than one evaluator review each program to avoid evaluator bias.

Another resource for evaluating courseware is *Guidelines for Evaluating Computerized Instructional Material* by Heck, Johnson, and Kansky. According to a review by Roblyer (February 1982), this thirty-two page booklet gives "some fairly general and usually practical advice on how to go about finding and evaluating materials." The authors intentionally avoid the "ten-item checklist" approach to reviewing materials, according to Roblyer, and have instead assumed that "products differ too greatly as to type and purpose, and that user needs for the same materials vary too widely to permit constructing such a checklist." It is up to the user, then, to determine and weigh the criteria to be used in evaluation. Roblyer suggests this booklet as a beginning step for those interested in obtaining quality educational software.

The importance of evaluating educational software before purchase and use cannot be overstressed, because there is a lot of shoddily produced software on the market today. A random sampling of what's available may easily lead an educator to believe that it's all useless. But as *Educational Technology* ("TECHnically Speaking. . ." April 1981) correctly concludes, "there are indeed some excellent programs available for purchase, both for instructional and recordkeeping purposes. It takes some work, however, to find those programs best suited to an individual school's curriculum, goals and objectives."

## INTEGRATING COMPUTERS INTO THE CURRICULUM

So you've conducted needs assessments, evaluated dozens or hundreds of software programs, purchased excellent hardware and software, and are beginning a schoolwide computer literacy program. Now what? Once their novelty wears off, will your computers start collecting dust in the school's resource room, or will they begin to fulfill their tremendous potential in the classroom? The answer depends in large part on the administrative action taken during this introductory period.

In this section, a few general suggestions for integrating computers into the curriculum will be presented. Further guidance for administrative action will be found in the next chapter, which describes how several schools and districts are successfully incorporating computers into everyday classroom life.

Wilson has recently outlined several valuable recommendations for two groups of administrators: "those who have not yet initiated computers into their curriculum; and those who already have classroom computers but are dissatisfied with or uncertain about curriculum development in this area."

As a first step, administrators should identify teachers and other school personnel who are interested in using computers in the classroom. "Be alert to the teacher who is taking an evening computer course at the local junior college," says Kara Gae Wilson. Survey faculty interest in computers and find out which teachers have purchased personal computers for home use. "When a teaching position opens, make a point to hire someone who has computer experience, has taken a course, or is at least open to training."

Once one or more faculty members have been identified, some formal training may be necessary. Even one good committed teacher, combined with a supportive administrator, is enough to start a computer curriculum.

The need for identifying these initial interested faculty members is crucial, says Wilson:

> Districts or buildings that begin with computer equipment instead of trained people in the classrooms are

attempting to force-feed a curriculum change. As with all good curriculum beginnings, the desire must come from a willing teacher, not just an eager administration.

Once the use of computers for instruction has become common in one or more classrooms, administrators should start getting other teachers and departments involved. "It is an administrative responsibility," says Wilson, "to see that computers do not become the exclusive domain of only one department (usually math), or one student level (usually honor students)." Computer use, Wilson continues, "must permeate all departments if it is to ultimately reach all students."

One way to get other teachers involved is to have those teachers who are already using computers tell their peers—through seminars or workshops—how their instruction is benefiting through CAI. Wilson also suggests that administrators encourage teachers to check out the school's microcomputer equipment for experimentation at home.

The continued use of computers for instruction after the initial novelty period wears off will depend on one critical factor: the availability of quality instructional software that fits into the existing curriculum. If only mediocre software is available or if computers are seen more as amusing toys than as useful instructional tools, their attraction will soon fade and teachers will quit using them. Thus, administrative action to locate, evaluate, purchase, and possibly develop quality instructional software is of the utmost importance.

In the future, school districts that have done their homework will have full libraries of computer-based instructional materials. Nearly every course will have a full complement of CAI materials to enrich and facilitate the teacher's actions.

Those "floppy discs" that now seem so new and unusual will someday soon be an integral part of the curriculum. And like any curriculum materials, they will constantly have to be revised, updated, and reevaluated in light of changing curriculum goals and design.

As is the case today, some districts in the near future may prefer to base their instructional programs on the curricula offered by the large educational publishers. The Houston Independent School District—described in the next chapter—takes this approach. The large educational publishers are already beginning to offer what they call complete computer-based educational packages for some subject areas.

Many other districts will likely want to design their own instructional programs, integrating materials from various publishers when it seems appropriate. In a world of computerized classrooms, these districts will have to train or hire personnel to design and write instructional software to complement the district's overall curriculum design. Many districts are already doing just this, such as the Lyons Township Secondary District described in the next chapter.

CHAPTER 4

# CASE STUDIES

Already 25,000 of the nation's 84,000 public schools use at least one computer for instruction, according to the 1982 Market Data Retrieval survey quoted earlier. By fall 1983, nearly half of U.S. schools are expected to have at least one computer.

The invasion of the classroom by the new electronic genies is proceeding apace. But how are individual districts and schools responding to the new teaching machine? What kinds of hardware and software are they using, and what subjects are being taught with computers? How are these schools and districts teaching computer literacy, and how are they integrating CAI into their educational programs?

This chapter attempts to answer these and similar questions by presenting several brief case studies of schools and districts that have begun to unleash the tremendous potential of computers in their classrooms. The patterns of implementation vary substantially, but in all cases there is one common element: strong administrative support and guidance for the implementation effort.

## LYONS TOWNSHIP, ILLINOIS

The Lyons Township Secondary School District in the southwest suburbs of Chicago currently has what may be the most developed computer-assisted instruction (CAI) program in the nation. This small high school district with 3,800 students currently boasts 232 TRS 80 microcomputers, giving a very impressive student/computer ratio of less than 17 to 1. Moreover, the district develops nearly all of its own courseware and already has an extensive courseware library that closely fits the district's curriculum.

According to Gloria Ekkert, a computer technical aide with Lyons Township, the district utilizes a three-part program of computer-related instruction. First, computer literacy is taught to all incoming freshmen in a four-hour minicourse.

This minicourse is for "acquaintance" purposes only; no programming is taught. Second, the district offers elective courses in computer science through the math and business education departments. Currently, BASIC, FORTRAN, and COBOL languages are taught, and PASCAL will be offered in fall 1983.

Third, and most important, the district has a well-developed CAI program that includes district-developed courseware for all departments, including visual arts, music, industrial technology, and home economics. Types of courseware include tutorials, simulations, and drill-and-practice.

The courseware design process operates as follows: teachers submit proposals to have a new program written or an existing program revised. The proposals are reviewed by the director of curriculum and instruction and the project director for computer curriculum. If a proposal is accepted, a time is set during the summer months for the teacher to work with a computer programmer to develop the program. The computer programmers hired by the district are college students in computer science. In the summer of 1982, according to Ekkert, four programmers and two central office staff worked full time for two months on numerous programs, with additional input from the various teachers involved.

The result of this well-conceived and apparently well-funded design process is a library of CAI programs that precisely fits the district's curriculum. An additional benefit is that teachers are much more likely to use CAI in their classrooms, because many are closely involved with courseware development.

The impetus for this ambitious CAI program, said Ekkert in a telephone interview, came from the superintendent, who joined the district in the early eighties. As will be seen in other case studies that follow, strong administrative support is an element common to all successful CAI programs.

## MIAMI LAKES, FLORIDA

Miami Lakes Junior High School (enrollment: 1,520) began its computer program three years ago, and today it is one of the best such programs in the populous Dade County School District (230,000 students in 250 schools). The success of this program is due to a combination of factors, including the full support of district administrators, strong guidance from the school's principal, an extraordinary computer teacher, and strong community support.

According to Miami Lakes' principal, Benjamin Miller, the school now has twenty Apple computers plus a few Ataris supplied by the district. What is unusual in this case is that the Apples were purchased largely with money generated by the school itself, through fund-raisers and community donations.

The first computers, stated Miller in a recent article, were purchased with money from the school's "internal account," which is built up by various fund-raising activities. "As soon as our classes were under way we began to notice amazing results," such as the rapid development of computer "whiz" kids and extremely heavy student demand for computer use. After a sophisticated demonstration by the computer classes during a "Back-to-School" night, "our fund-raising efforts, which had earlier failed to stir any interest, suddenly took off as influential parents and local businesspeople became actively involved."

The school's computers are used in three main areas: computer literacy, computer science, and CAI. Currently, the CAI applications are limited primarily to vocational education, science, and math, but eventually, said Miller in a telephone interview, CAI will be used in the language departments and throughout the school.

The software used by the school is mostly purchased. As a matter of fact, the school's choice of hardware was determined in large part by the availability of extensive software for the Apple microcomputer. Today, Miami Lakes has the most extensive software library in the district, according to Miller.

When teachers want to use CAI, they check what's available in the software library or order materials with the assistance of the school's computer instructor. Additional evaluative input is provided by the Miami Apple User's Group, of which most of the school's computer-oriented instructors are members.

Teachers are trained to be computer-literate through a voluntary inhouse training program. So far, twenty of the school's sixty-two teachers have taken advantage of the program, and several have gone back to school to get their master's degrees in computer-based education. As Miller concluded, "they know they'll be missing the boat if they don't learn about computers now."

## HOUSTON, TEXAS

The Houston Independent School District (enrollment: 193,000) is committed to using computers for instruction—so much so that the district has created a "Department of Technology" and the nation's first associate superintendent of technology, Patricia Sturdivant.

According to a telephone interview with Assistant Superintendent of Technology Patsy Rogers, Houston is currently using 800 Apple microcomputers and plans to have 500 more in service by fall 1983. In addition, the district is experimenting with other makes, including IBM's personal computers, Radio Shack's TRS-80, and Texas Instruments computers.

Houston Independent purchases most of its courseware from the large educational publishers. Most of this courseware is of the drill-and-practice and remediation types because, said Rogers, "that's all you can find on the market."

At one time, the district used twenty-five PLATO terminals. PLATO, as explained earlier in this digest, is a time-share system offering thousands of hours of high-quality tutorial software. But because of the high cost of PLATO—about $9,000 per year per terminal—Houston now leases only one or two PLATO terminals.

Advertised software is evaluated by a software committee made up of people from every department in the district. Many of these committee members have received extensive training in software evaluation from a Washington, D.C.-based software publishing house.

The Department of Technology wants to make sure that the district's limited computer resources are used efficiently. Thus, it requires the schools to submit implementation plans when they want to use CAI. The implementation plans must specify goals for CAI, target populations, and so forth. If the plan is approved, the principal must have twenty hours of computer literacy training. The principal must then designate two teachers to receive sixteen hours of hands-on training in computer use.

## CUPERTINO, CALIFORNIA

In Cupertino—the home of Apple computers—educators are already well on their way to making the use of microcomputers an everyday reality of classroom life. In fact, the use of microcomputers is already so integrated into the curriculum of the Cupertino Union School District (enrollment: 12,000 in 19 elementary and 4 junior high schools) that the usual distinctions between computer literacy, computer programming, and computer-assisted instruction are almost lost.

Students first learn how to use computers in kindergarten and first grade, much as they would learn to use other classroom learning aids. These young students are taught to use LOGO, a simple, graphics-based computer language designed to build problem-solving skills. The students become computer literate, learn a programming language, and learn problem-solving skills, all at once. This process is expanded in the fourth grade when students are taught a more advance programming language called PILOT.

In seventh and eight grades, students take formal computer literacy classes in which they learn how computers work in general and how to program in a structured BASIC language. "We think it's important that they learn good programming practice," said Cupertino's computer resource teacher, Bobby Goodson, in a telephone interview, "which is why we use the structured BASIC (which is very similar to PASCAL) instead of regular BASIC."

"But teaching computer programming itself," she was quick to add, "is a very low priority. We are teaching programming, but primarily as a basis for other things such as problem-solving and computer literacy. We have no desire to make programmers out of our students."

Computer programming at Cupertino, then, is treated much like any other basic skill. "Students get a very good introduction to it here," said Goodson, "and if they choose they can pursue computer programming further in the high school."

Teachers as well as students at Cupertino are trained to consider computers as immediately useful tools instead of "black boxes" that can be of value only if their inner workings are mastered. "The computer is a tool that the teacher uses, along with a whole lot of other tools in the regular teaching process," Goodson emphasized. Teachers are taught how to use computers, but learning how to program using authoring systems is left as an optional inservice topic.

Besides, said Goodson, "good teachers don't have time during the school year to write good software—it's just too time-consuming." As might be expected from this philosophy, the schools in Cupertino develop little of their own courseware. Instead, most of the software used on the district's 225 microcomputers (only half Apples—the rest are Ataris) is purchased from commercial vendors.

So far, the district has purchased most—but not all—of the microcomputer hardware used in the district. Most of the software, on the other hand, has been purchased by the individual schools with funds that have been set aside out of their budgets, or with money from fund-raising events.

Of course, with so many schools purchasing their own software, there is a significant danger of obtaining poorly written educational courseware, which still represents the majority of available software. "Programmers without teaching experience *obviously* don't know what's needed in the classroom," said Goodson. "All you have to do is look at some of the software on the market to know that."

To protect against bad purchases, a board of district teachers is being set up to screen all software purchases and warn against bad programs. Most existing educational programs that are "good" are already known by someone on the board or by the Computer Using Educators (CUE), of which Goodson is also president. When an untested piece of courseware is being requested, the board makes sure it can be bought on approval. "We will not buy sight unseen," she insisted.

The main problem faced by the Cupertino schools is still finding good courseware, said Goodson. "It is only now that really good software is beginning to come out." Overall, though, the five-year old computer program at Cupertino is going well. "It's not easy," she concluded, "but it's great."

## CONCLUSION

The much-hailed computer revolution is finally upon us. Even the ever-stable public schools are being swept up in the tide of societal change spawned by computer technology. Schools everywhere are beginning to use the new teaching machines to improve their instructional programs and move closer to the goal of individualizing instruction for every student.

What does the future hold? Educator's fears notwithstanding, computers will not "take over" the jobs of teachers and administrators. Rather, as the eighties and nineties unfold, computers will come to be seen as valuable teaching tools—indispensable aids that will greatly enhance each instructor's classroom effectiveness.

School administrators can take two approaches to the new world that lies ahead: they can wait passively and perhaps defensively for the changes to overcome them or they can accept and actively prepare for the inevitable metamorphosis of public education. Needless to say, this digest advocates the second course.

The information presented in the preceding pages is intended to help educators—particularly administrators—prepare themselves and their schools for the world of the late eighties and early nineties. But this is not enough in itself.

Administrators must keep themselves constantly tuned to the changing world in which they live, especially to advances in technology and their implications for education. They must personally envision how their educational system can be better next year. And they must actively plan and implement strategies to get their schools from here to tomorrow. Using such a future-oriented approach, administrators can fully tap the tremendous potential that the world of tomorrow has to offer.

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