CAI EFFECTIVENESS AND ADVANCING TECHNOLOGIES:

AN UPDATE

SPONSORED BY ICIA'S EDUCATIONAL COMPUTING COUNCIL
CAI EFFECTIVENESS AND ADVANCING TECHNOLOGIES: AN UPDATE

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Preface

"CAI Effectiveness and Advancing Technologies: An Update" was prepared at the request of ICIA by Education TURNKEY Systems Inc., a firm which conducts market research for hardware manufacturers, publishers, and government agencies involved in educational technology and related areas. The principal authors of the paper are Charles L. Blaschke, president of TURNKEY and 20-year veteran of the computer-based education movement, and Charles E. Watson, research associate with TURNKEY.

The Educational Computing Council of the International Communications Industries Association

The Educational Computing Council is the software arm of the International Communications Industries Association (ICIA), dedicated to improving and upgrading instructional materials used in education and to providing educational programs and networking opportunities for dealers and end users. The Educational Computing Council serves as a clearinghouse of information, and through its conferences and newsletters keeps members up-to-date on educational needs and concerns. The goal of the Educational Computing Council is to offer a united voice in the area of instructional materials and to meet the needs of all within the instructional materials field.

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INTRODUCTION

In “CAI: The Bottom Line”, we suggested that hardware and software vendors’ bottom lines would increasingly depend upon hard data which clearly demonstrates the effectiveness of CAI use in public schools. While many school officials are taking a wait-and-see attitude, most are now asking even tougher questions about the relative effectiveness of CAI and related computer-based educational programs and networks.

One purpose of this paper is to provide an update on recent findings related to the cost-effectiveness and other effects of computer-assisted instruction, primarily in the K-12 market. While only a few recent studies have been completed during the last year, the results of several of these studies (e.g., Project IMPAC) have been very promising and reinforce many of the previous findings related to the use of CAI in supplementing basic skills development. Other studies have focused on the effects of tutorial and simulation programs, also reporting positive gains. And, because of the increased interest in networking, the findings from several CMI “network” projects are also reported.

Over the last couple of years, interactive video, telecommunications, and microcomputer technologies have begun to converge, resulting in expanded capabilities and increased use in schools. This paper also describes recent advances in the use of videodisc, CD-ROM, distance learning, and various means of electronic distribution being piloted in projects across the country. Some implications of these, mostly complementary but often competing technologies, for schools and hardware and software vendors are noted.

RESEARCH FINDINGS ON COMPUTER-BASED INSTRUCTION

Results from CAI/CMI evaluations conducted in the past year continue to show that computers can reduce student time to achieve instructional objectives and/or increase student performance.

Cost Effectiveness of CAI and/or CMI

A small number of research studies have addressed the cost-effectiveness of CAI and/or CMI over the last year.

As a result of State legislative requirements, the Arkansas Commission on Microcomputer Instruction is conducting Project IMPAC (Instructional Microcomputer Project for Arkansas Classrooms) in an effort to find cost-effective ways to use microcomputers to improve the teaching of basic skills at the elementary school level. Project IMPAC includes four specific programs being tested in Arkansas school districts. More than 100 school teachers and over 2,800 students in grades 4-6 participated in this study. Four types of programs were evaluated involving: (1) computer-managed and computer-assisted instruction on a microcomputer network; (2) computer-assisted instruction similar to the first mode, except based on floppy discs and with much less emphasis on the computer management; (3) microcomputer-based skills laboratories using equipment and software similar to the first mode, but in a laboratory setting rather than in the classroom; and (4) a specially designed basic skills testing and prescriptive program for mathematics correlating with the Arkansas Basic Skills Objectives.

After two years, a number of findings and recommendations based on the findings were reported by McDermott:

- Students in Project IMPAC made yearly gains of two to three months more than expected gains in mathematics, reading, and language arts.

- The ratio of CAI time to regular instruction should be about one to four for a total of 1,100 to 1,300 minutes during the school year. Excessive CAI (over 1,500 minutes per year) showed greater improvement than the control groups in the subject being treated, but it appears the gains were achieved by neglecting other subjects. Limited use of CAI (less than 700 minutes) was not cost-effective.

- Students in self-contained classrooms made the most academic progress and adapted to the program best. In a departmentalized setting, more microcomputers were required to give students sufficient time on task with CAI, reducing the cost-effectiveness of the program. In schools with departmentalized instructional settings, consideration should be given to establishing a laboratory CAI/CMI hard disk network program.

- Maintenance and repair of equipment can lead to teacher frustration. Project IMPAC experienced an 11 percent equipment failure rate during the year of experimentation. A three- to seven-day turnaround time was achieved by using overnight delivery services, which kept teacher frustration to a minimum. It was also found that more precise electrical requirements for networking machines created problems.

- Computer literacy training in elementary schools is the least effective use of computers. The most cost-effective use is for basic skills, problem solving, and enrichment activities which supplement regular instruction.

- Grades four through eight should be given the greatest priority for basic skills CAI. A suggested min-
imum program is for two consecutive grades with a maximum of two subject areas.

MacArthur (1986) has found that, during CAI learning, disabled students spend significantly more time on task than during seat work. Observations also show that teachers spend more time helping students with task-related problems during CAI. At least some of the differences in achievement between CAI and traditional instruction may be due to the greater time on task. Students using CAI attributed their gains to the computer, while students in traditional settings credit their success to ability and effort.

When teachers are trained to use computers effectively, the value of computer-based instruction increases

Haynes (1986) has found that LD students using CAI seem to be less aware of the current state of their learning, and are, therefore, less able to use appropriate strategies to enhance their learning. Since many CAI programs do not allow students to control the rate, order, or content of their practice activities, LD students fail to monitor their own learning. It is also possible that feedback from CAI programs does not require sufficient attention of students for it to be strategically useful.

Reith reports that the amount of teacher-based instruction decreases as the amount of computer-based instruction increases. As teachers are trained to use computers effectively as part of the instructional program, the value of computer-based instruction increases.

Critical Thinking

The Higher Order Thinking Skills (HOTS) found that computers can significantly increase the ability of students to construct sophisticated associations between ideas. HOTS specifies day-to-day instructional activities in a computer lab, along with effective teaching techniques to maximize the potential for generalizing. Although students who were behind in both math and reading did not improve higher order thinking skills using computers, students substantially below grade level in either showed improvement. Pogrow suggests that language development is the crucial factor determining success in the program. Because of this, students below the fourth grade were not recommended for inclusion in the program.

Norton and Resta (1985) found that computers can be used to provide problem-solving strategies better than in print materials for inductive thinking, reasoning in an open system, systems thinking, what-if reasoning, synthesis reasoning, and pattern recognition. Students were given one of three types of computer-based reading instruction: computer-assisted instruction; problem solving software; and simulation software. Results indicate that students entering the upper elementary school grades show greater reading gains from problem-solving and simulation software than from more traditional skill-oriented software. Students entering the third grade showed no difference among the three treatments. Norton and Resta postulate that the difference may be attributed to the fact that problem-solving and simulation often require mental abilities beyond those of younger children.

Gersten (1986) has concluded that teaching disabled students can acquire complex skills, such as logical reasoning, in a tutorial format, provided the software includes a strategy-based feedback mechanism that not only corrects the student's error, but offers a series of steps or questions explaining the situation. When working with LD students, the size of practice units and the review schedule has a significant effect on the acquisition of knowledge.

Tool Applications

Use of tool applications has increased dramatically during the last two years as teachers are beginning to integrate word processing, spreadsheet, and related applications into various curriculum areas. The effects and effectiveness of tool use with students, especially word processing packages, look promising even though few large-scale evaluations have been conducted.

In a study comparing use of a word processor with rewriting by hand, Levin (1984) found that rewriting pencil-and-paper drafts for elementary students may even have a negative effect on improving an article due to new errors being introduced as old ones are corrected. Sitko has found that mildly handicapped children wrote integrated stories of greater length and had increased "self-esteem" about writing as a result of using word processing. Hummel reported that children with learning disabilities made gains in the length and organization of written items, and increased the amount of time spent writing and the amount in focused participation. Students showed more interest in writing and self-confidence as writers. Morocco (1986) observed that, in the remedial setting, teachers overemphasized the editing capabilities of word processing software, interrupting the writing process too soon for editing.

CMI and Networks

Interest in networking has increased during the last year (TALMIS, 1985). Early in 1986, IBM announced its Advance Netware network system and, in June, it announced PC CLASS, a generic instructional management system. Also in June 1986, Radio Shack and Education Systems Technology Corporation announced their most recent network CMI configuration which includes a K-6 math and reading series. A new network configuration is expected to be announced by Apple in the future. Several recent evaluations indicate that microcomputer-based CMI networks continue to demonstrate gains similar to those demonstrated on the more costly minicomputer configurations used in the 1970s.

A study by the Western Kentucky University (1986) has shown that students receiving 10 minutes of CAI per day for 150 days a year receive achievement gains of 1.2 to 1.4 years. The Federally-funded study used Computer Curriculum Corporation software at 23 Kentucky middle schools with 1300 students. The greatest gains in achievement were made
Most students gave high ratings to CAI before using the system and afterward, though primary students modified their ratings downward after using the system. Intermediate students remained the same after using the system.

Ryan has identified the differences between districts using computerized Individualized Education Plan (IEP) writing, including: (a) the attitudes of teachers towards IEPs, (b) the time spent in IEP preparation, and (c) the cost per IEP. Her findings are that computerized IEP preparation saves a significant amount of time (65 minutes vs. 118 minutes), that teachers using computerized IEP systems have a more favorable view of the value of IEPs, and that the computerized IEP districts have a lower average IEP preparation cost ($67 vs. $84). In summary, the recent evaluation findings of computer-based instruction and management systems corroborate findings reported earlier. Concurrent with expanded microcomputer use, a number of other members of the education technology family are beginning to be used in public schools. Where evaluations have been conducted, these technologies also appear to be demonstrating varying degrees of instructional effectiveness.

ADVANCING TECHNOLOGIES
POTENTIAL AND IMPLICATIONS

Advances in microcomputer and related technologies and the large base of microcomputers now in public schools have opened up new opportunities for other members of the education technology family including videodiscs, CD-ROM, interactive video, and telecommunications systems. Technologies such as CD-ROM provide not only complementary capabilities, but also can be considered a competing technology in some areas. Below we discuss some of these technology advances, their current and potential uses, and some of the implications for software publishers and public schools.

Videodisc

Overshadowed by the rapid growth of VCRs in public schools during the last year, the educational videodisc has made a "beachhead" in education. Until recently, schools were unwilling to purchase videodisc hardware until educational programs became available, while software publishers hesitated to invest in the high cost of videodisc program development until an equipment base in the schools existed. Over the last year, primarily through venture capital and with some Federal funding, the number of educational videodisc programs has increased dramatically. There is a current base of more than 175 discs ranging in subject from art to math to science, as displayed in Exhibit 1. Until last year, more than 90 percent of all videodisc programs were custom-developed for military and industrial use. For a variety of reasons, recently risk-taking publishers have invested in programs for the school market. The videodisc hardware base has increased to between 6,000 and 8,000 units (TALMIS, 1985; TURNKEY, 1986). Market niches are opening up as the result of projected teacher shortages—particularly in math and science—where the simulation capabilities of videodisc are ideally suited to the subject matter. Moreover, unlike microcomputer software, unauthorized copying of videodisc programs is much more costly and difficult.

Virtually all educational videodisc programs operate on laser disc players. Some programs are designed to operate on lower-priced, consumer (e.g., Level 1) laser discs costing approximately $500, while others (referred to as Level 3) are designed to operate on higher-priced videodisc units interfaced to microcomputers. Some programs can operate on both videodisc configurations with appropriate interfaces and "authoring" programs.

Instructional applications of videodiscs include: direct instructional programs which can be integrated into a specific curriculum; instructional simulations, usually requiring Level 3 configurations; and "picture discs" which store slides, pictures, and video sequences. Up to 54,000 frames on one side of a disc can be accessed in less than two seconds.

One of the most comprehensive, direct instructional programs is Core Concepts Math and Science, developed and published by Systems Impact Inc. Designed for use in small or large groups, the programs (accompanied by a teachers' manual and support materials) are easily integrated into, for example, a traditional math classroom environment and can be quite cost-effective because it operates on Level 1 videodisc hardware.

Instructional simulation programs are primarily designed for use in biology, chemistry, physics, and related science curriculum areas. Examples include chemistry laboratory experiments available from the Great Plains ITV Library and Voyage of the Mimi marketed by CBS. Maryland Instructional Television recently released "The Business Disc" program designed to instruct would-be entrepreneurs on how to set up a small business. This program simulates interactions among bankers, lawyers, accountants, and customers through both the videodisc and microcomputer. The Texas Technology Learning Group, a consortium of the Texas School Boards Association and local
school districts, is developing a physical science videodisc program for high school students. IBM Corporation recently announced its InfoWindow system which includes a sophisticated authoring/presentation package; it has been pilot tested in Kentucky and elsewhere. Adult literacy is a priority focus of IBM's ventures into videodisc development. Apple and National Geographic recently announced a joint videodisc development venture.

Other videodisc applications include picture discs, of which the Bio-Sci program published by Videodiscovery was one of the first on the market. The National Gallery of Art

Interactive video use has resulted in positive user attitudes, reduced time in achieving objectives, and—in many cases—increases in student achievement.

archival videodisc includes a pictorial and descriptive record of more than 1,500 paintings and sculptures. The "Knowledge Disc" published by Grolier Electronic Publishing contains its 21-volume encyclopedia on videodisc for about 20 percent of the cost of the printed version. Several videodisc programs provide career guidance and counseling. These include: Discovery for School, Pathfinder: A Career Decision Process, and College USA which provides "campus tours" and assists students in selecting colleges and obtaining financial aid.

The potential costs and time savings (and safety factors) associated with using videodisc for laboratory experiments can be considerable. While few programs have been used in schools long enough for thorough evaluation, several evaluations using achievement tests were recently completed. As reported at AERA's recent annual meeting, Hofmeister, Engellman, and Carnine found significant differences between students receiving two treatments: one using interactive videodisc and Core Concepts' Mastering Fractions series; the other using lessons from a basal text.

Using the same technology as digital compact audio discs, CD-ROM can hold more than 550 megabytes of digital data—roughly equivalent to information on over 200,000 single-spaced pages or 1500 floppy discs. Thus far, the only educational application on CD-ROM format is the Grolier Academic American Encyclopedia (AAE), which sells for $199 and contains the equivalent of 21 printed volumes. The AAE is also "on-line" through CompuServe, which facilitated the transfer of files to CD-ROM format, one of the barriers constraining development and production of CD-ROM programs. While hardware standards have been established, similar standards for file managers and interface peripherals are necessary before publishers are likely to invest significantly in CD-ROM programs.

The concept of CD-ROM with reference and archival material can be easily grasped by school media specialists, librarians, and instructional staff. When CD-ROM is actually demonstrated, staff expectations regarding its myriad applications in schools expand considerably, almost to the point of being unrealistic. Ease of use, instantaneous access, text editing capabilities, and massive storage capacity are among the key features which will entice educators to use this technology. Reference materials such as Grolier's AAE in a CD-ROM format will increasingly become economically feasible to schools as the price of CD-ROM disc drives can be expected to decline and the availability of interface peripherals for several brand name computers increase. Approximately 20 publishers are currently developing CD-ROM programs which can be used in public schools. These include reference materials and guides published by Bowker and H.W. Wilson. When it becomes technically and economically feasible to include graphics on CD-ROM formats, it is conceivable that all of a software publisher's CAI programs could be encoded on one CD-ROM digitized disc. One Maryland school district in the Maryland Education Technology Network (METN) project is using the AAE CD-ROM in the IBM local area network.

CD-ROM

The phenomenal growth over the last year in audio compact disc suggests a strong potential for CD-ROM (Compact Disc - Read Only Memory) in education over the next five years.
relying the use of a microcomputer, CD/I is an intact unit which allows the use of audio, television pictures, animation, and text via interactive programming but does not store motion video. Most experts believe CD/I will first enter the home as a replacement for the audio compact disc and then, perhaps, reach the education market in areas such as art, music, and vocational education (Brewer, 1986).10

Distance Learning

During the last year, the number of students participating in distance learning projects across the country has increased at a greater rate than the number of students receiving instruction via microcomputer during the early 1980s. This phenomenal growth was the main topic of the annual CCSSO Technology Conference in February 1986. Distance learning models usually involve: (1) interactive video, audio, and graphics; (2) satellite or other broadcast means; (3) a master teacher in one location; (4) students at remote locations (schools) with broadcast receivers; and (5) student access to microcomputers for drill and practice. The growth of distance learning projects over the last year can be attributed to a number of factors. Advances in technology now provide cost-effective opportunities for the convergence of telecommunications, microcomputers, interactive video, and related technologies. Due to significant investments in broadcast TV and cable systems during the last three decades, the availability of a telecommunications infrastructure within the states and regions provides opportunities for distance learning with little start-up costs and low marginal operating costs. Through the use of master teachers, distance learning—in many cases—provides the only opportunity for students to receive courses which are now required in many states (due to increased standards for graduation) and to take advantage of the rapidly growing Advanced Placement Program. In rural, poor, and small districts facing consolidation, distance learning provides, in many instances, the only economically viable alternative for meeting state requirements and survival.

Some of the same states which took a lead role in the microcomputer movement have initiated path-breaking distance learning projects. In New York, nine projects involving 40 districts are currently underway; another 25 projects involving over 300 districts are in planning stages. These projects involve interactive instruction in science and math, particularly for advanced placement programs. According to Greg Benson, director for the Center for Learning Technologies, the cost to a school ranges between $1,000—if the school has existing cable capacity—and $20,000 for a school without it.10

Distance learning in Utah focuses upon language instruction in Spanish. Sponsored by the Utah State Board of Education, Bonneville Inter-

In many cases, distance learning provides students the only opportunity to receive required course work economically

national Corporation and IBM Corporation, this pilot study relies on low-cost, wide coverage satellite transmission, master teachers, twoway audio, and one-way video with opportunities for direct student interaction with microcomputers in a local area network. Student reference and teacher print materials are available. Preliminary results reported at IBM's first annual Publishers Conference in June 1986 suggest significant savings in student time in mastering Spanish.

In Minnesota, seven small school districts have formed a distance learning consortium which relies on two-way fiber optic video for transmission. Courses are being offered in Spanish, French, accounting, and music. A major objective of this project is to access the increased quality of video, telephone, and computer transmission using fiber optics, which is more expensive than hard cable or microwave.

While some states (e.g., Michigan) have relied on traditional public broadcasting systems, other states (e.g., Texas) have established relationships with private firms—such as TI-In Network Incorporated—to provide distance learning to approximately 100 districts within the State. TI-In provides instruction via satellite from master teachers in the TEA Region XX Service Center studio to districts which pay approximately $15,000 for equipment, monitors, printers, and telephone costs during the first year; subsequent annual costs are about $10,000. Course offerings cover a wide range of curriculum areas and include staff training and personal business offerings for teachers.

Technology advances, building upon existing telecommunications infrastructures, have made two-way, audio/video, interactive distance learning a reality. In some configurations—such as the Utah—IBM-Bonneville pilot study—microcomputers are an integral part of the student learning environment. In other configurations, distance learning may be considered a competitive technology with computer-based education, particularly in states that have ITV agencies with a narrow view of their mission. Nevertheless, with the convergence of microcomputers, telecommunications, and interactive video, new opportunities for publishers may be created for differentiated products presented in alternative formats with different packaging and provided under license arrangements.

Electronic Distribution

Physical distribution of software continues to be costly. The availability of various telecommunications systems offers substantial opportunities for electronic distribution of software. The Concept

Electronic distribution of educational courseware, a simple concept offering enormous potential benefits for users, publishers, and developers, is slowly becoming a reality. Technical and other problems are being resolved as many states have undertaken a variety of initiatives relying on different telecommunications transmission means. Proponents of electronic distribution and "education utilities" have expended the potential benefits accruing to states, schools, and publishers.

- The potential benefits for school district users include:
- access to courseware for special needs students (e.g., special education, bilingual) with payment based on use;
- opportunities for reducing administrative time and costs associated with inventory control, maintenance of diskettes, fragmented purchasing, etc.; and
- availability of electronic mail and other means of communications within the district.

- For state education agencies, electronic distribution provides opportunities to:
  - use existing, underused state-wide telecommunications networks;
  - review supplemental courseware packages and programs to ensure compatibility with and integration into state-wide curriculum guides; and
  - make large discount purchases.

- For producers and publishers, electronic distribution provides opportunities for:
  - reducing preview, marketing, and distribution costs;
  - increasing revenue for user-friendly, high quality courseware packages with royalty payments based upon usage; and
  - field-testing and validating programs in operational settings and for subsequent upgrading in a cost-effective and timely manner.

In addition, certain types of electronic distribution also provide opportunities for distributors and publishers to transmit courseware packages to dealers and sales representatives, thereby minimizing dealer warehousing and inventory costs.

While a number of electronic distribution configurations are being pilot tested and others are being planned, none currently provide opportunities for all of the above benefits to be realized.

**State Initiatives**
A number of states are experimenting with different electronic distribution systems. The West Virginia State Department of Education acquires commercial software and/or public domain courseware and distributes the program by telephone lines through its state-wide IBM network to the school building level. This system also has an electronic mail/bulletin board system used by teachers. In Wisconsin, the state education department is experimenting with the use of FM radio SCA, deregulated by the FCC in 1983, to broadcast public domain software to a number of school districts. This project is funded by the Secretary of Education’s discretionary program, as well as by state funds. Plans are underway in New York and New Jersey to conduct pilot demonstrations relying on the use of the state ITV network in New Jersey and a combination of broadcast means in New York.

The Maryland Education Technology Network (METN), operated by the Maryland State Department of Education (MSDE)/Division of Instructional Television, is perhaps the most advanced, operational pilot study of broadcast distribution of courseware. During the 1985-86 school year, the IBM Corporation installed local area networks in a school in each of five districts and is installing a broadcast/electronic mail capability for distributing courseware to all seven sites. The second audio portion (SAP) of Maryland Public Broadcasting signal will be used to transmit courseware and data files to each of the receiver-equipped sites. In June 1986, MSDE and its contractors began experimenting with alternative broadcast bauld rates to assess the technical quality and security of transmission and to develop benchmarks for deciding which of several alternative transmission means was most cost effective for different types of files (e.g., core curriculum packages, supplemental packages, electronic mail, data bases). As of June 1986, over 150 courseware packages from approximately 15 publishers have been licensed for use on local area networks in the METN sites. Plans include possible renegotiation of licenses with publishers if (and when) metering capabilities are available. The METN project was prominently displayed at the first IBM-sponsored Publishers Conference in June 1986 where IBM’s vice president, James E. Dezell, Jr., expressed IBM’s strong intention to support networking in public schools as an efficient means of courseware distribution.

Following the leadership of MSDE, the Software Communication Service—a consortium of 15 states and several Canadian provinces—was created in June 1986 to acquire, store, and distribute education software, using alternative electronic means, to local education users. This consortium, supported by educational television agencies and state departments of education in each of the participating states, represents an attempt to aggregate the software market and provide low-cost means of software distribution.

In addition to state involvement in electronic distribution of software to local school systems, a number of private ventures offer electronic distribution services for publishers and their dealers. GEISCO’s Dealer Talk system provides electronic distribution of courseware from publishers to dealers. Nabu, Control Video, Selec-tex, and others have conducted market tests of electronic courseware distribution directly to home computer users and to some schools. In the last year, GTE Telenet has distributed software to businesses through its network. Relying on Telenet’s PC Sunet, National Systems Management Inc. will soon provide SpecialNet users (more than 3,000 school districts) opportunities to review software for a nominal charge prior to purchasing.

**Implications**
Advances in the use of videodiscs, telecommunications, interactive video, CD-ROM, and related technologies raise a number of implications for school district users and software and hardware vendors.

Given the rapid changes in technology and its use, and the emergence of competing technologies, implications for school officials are significant indeed. More than with microcomputer use, in-depth, comprehensive planning in combination with good “crystal ball gazing” is critical. Each of these technologies has its strengths and limitations, with each susceptible to sudden technological shifts and linkage capabilities with converging technologies. Monitoring technology and use trends will be critical. For example, when standards are established for CD-ROM, will this technology be used primarily for reference and archival purposes or will it
be used for student instruction in direct competition with videodiscs? School officials must consider the tradeoffs between the decreasing costs and expanded capacity of resident data base storage in local area networks and participation in wide-scale electronic distribution from centralized points. As intrastate or interstate broadcast capabilities emerge, political sensitivities relating to courseware selection and content will arise. Budget and finance implications for metering usage must be addressed. As school districts participate in distance learning projects, school policy makers should be clear in their own minds whether this constitutes a long-term venture or a stop-gap measure to meet current teacher shortages.

For publishers and developers, there are both positive and negative implications. The emergence of distance learning and state-level electronic distribution, in combination with local area networks, inevitably will require publishers to formulate sets of state-wide license policies and pricing arrangements will be needed, requiring renegotiation of developer royalty payments. Electronic distribution may also change significantly the services provided by dealers. For small- to medium-sized publishers and developers, electronic distribution, combined with centralized procurement, can significantly reduce marketing, distribution, and sales costs. On the other hand, additional costs may be incurred in reformatting and repackaging software and documentation.

**CLOSING COMMENTS**

The findings and conclusions presented over a year ago in "CAI: The Bottom Line" are supported by a number of recent evaluations of microcomputer-based instructional programs, particularly those related to CAI supplemental programs. Well implemented programs using tutorial and simulation programs are reporting findings that will help schools to utilize the expanding capabilities of the microcomputer. While microcomputer-based CMI network configurations appear to be demonstrating improvements in student achievement, their potential in reducing staff time and facilitating individualized instruction has not been carefully assessed. Over the last six months, major hardware vendors—in collaboration with publishers—have announced network configurations which should be easier to use than their predecessors and accommodate generic instructional management systems to facilitate effective integration of courseware and supplemental materials into core curriculum areas.

The convergence of interactive video, telecommunications, and laser disc technology with microcomputers offers enormous potential for education. While many of the technical problems related to information utilities and electronic distribution are being resolved, managerial and organizational innovations (i.e., the creation of consortia) may be required to aggregate markets. The degree to which distance learning is dependent on teacher shortages or can provide a long-term solution to fundamental education problems is not clear. The number of education videodisc programs has increased dramatically over the last year, as has the equipment base in the public schools. Findings from limited evaluations of school-based programs are encouraging and tend to corroborate findings from large-scale use in industry and military training environments. Clearly, CD-ROM is the "hottest" technology item at technology conferences and is demonstrating its potential in library and reference services. The future of CD/I in education is largely dependent on standards established by hardware vendors and the utility of consumer software products in education. However, because of the tremendous capacity and flexibility of CD/I, some education publishers and developers are deferring new product development on CAI and CD-ROM formats until more is known about CD/I. The emergence of competing technologies and technological uncertainties continue to make school district decision making in the technology arena difficult.
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**Sources:**
References


