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ABSTRACT

This two reviews of the literature on computer-assisted instruction (CAI) are intended to provide a general outline of the major issues involved in the use of computers in education. The 1986 review focuses on definitions, computer usage, achievement gains, staff development, and trends, while the 1986-87 update focuses in particular on the results of the Second National Survey of Instructional Uses of School Computers. (Conducted by Henry Jay Becker, this large-scale study of computer use, teacher attitudes, and educational outcomes, provides information on patterns of computer use and effectiveness in U.S. schools.) The update also describes several programs that have shown learning results from the use of CAI, cost effectiveness data, suggestions for implementation, and future trends. The 1986 report is supplemented by several graphs, and charts and references are provided. The 1986-87 update includes as an appendix a checklist for monitoring instructional use of computers that was developed by Marilyn Coe. (83 references) (EW)

COMPUTERS IN EDUCATION

Hinsdale District #181

May 1986

A 1986-87 Update

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INTRODUCTION

The purpose of this report is to summarize the literature on computer-assisted instruction (CAI) that has appeared in print since the previous review was completed by IER for Hinsdale District #181 in May of 1986. This area continues to be one of considerable interest and activity in the educational community, although empirical research data are not as abundant as theories about computer use.

Consequently, much of this update focuses on the Becker Report, a large-scale study of computer use, teacher attitudes, and educational outcomes, which has been in process since 1983. This report is the largest and probably most definitive source at present which describes patterns of computer use and effectiveness in this country's schools. In addition to the Becker findings, this update includes a description of several programs that have shown learning results from the use of CAI, cost-effectiveness data, suggestions for implementation, and future trends.

THE BECKER REPORT

Since June 1986, results have begun to be made available from the Second National Survey of Instructional Uses of School Computers, the most extensive survey on school computer use to date. Conducted by Henry Jay Becker at the Johns Hopkins University Center for Social Organization of Schools, the study gathered information from a survey of more than 10,000 teachers and principals in over 2,100 U.S. elementary and secondary schools during the Spring of 1985. The results of this study are being published in a series of 6 newsletters, three of which are available as of January, 1987. The series will conclude by the spring or summer of 1987, and is available from Computer Survey Newsletters, Center for Social Organization of Schools, Johns Hopkins University, 3505 N. Charles St., Baltimore, MD 21218. The issues to come will deal with math and science education; computer programming and computer literacy; and writing, language arts, social studies, and vocational applications.

Reference was made to the findings of this study in the original CAI literature review, based on a preliminary report made by Dr. Becker at a conference in April, 1986. The Johns Hopkins newsletter average 16 pages in length, with about 50 pages published to date on the Becker study. The following six pages provide a summary of this material, focusing on those points most salient to a district like Hinsdale.

<u>Allocation of Resources</u>

The Becker study found that the number of computers in schools increased from 250,000 to 1 million between 1983, when an earlier survey was conducted, and 1985. During 1984-85, 15 million students and 500,000 teachers used computers as part of instruction programs. In spite of this, computers have had surprisingly little academic impact, and the study suggested this may be because of the way schools have implemented computerized instruction. Few elementary schools, for example, were found to use computers systematically to practice lessons learned in reading and math. And only 6 percent of the schools have 15 or more computers, not even enough for one entire class.

The study points out that the amount of computer time that students should have is a complex issue. The effectiveness of CAI depends not only on the quality of software, but also on

* how well computer activities are integrated into other instructional activities; and

* whether there are alternative and less expensive ways that students can achieve comparable academic competencies and understandings.

The study suggests that the optimum allocation of computer time is likely to increase over time, and may vary for children of different ages, prior backgrounds, abilities, or preferred learning styles.

For example, even today under the right conditions, a typical high school student could profitably use computers for writing compositions, to help in memorizing facts, for understanding relationships and concepts in math and science courses, and for writing computer programs. These researchers suggest that EACH of the uses just listed might occupy 30 minutes to 3 hours of computer time per week. Thus, a high school student might profitably use computers for an hour or two PER DAY.

However, according to the study, hardly a school in the country has the computer resources to give that much computer time to each of its students. To provide even 30 MINUTES of computer time per day to all students enrolled, a school would need to have one computer for every 12 students, and then the computers would have to be in constant use for 6 hours per day with no time lost to transitions or other interruptions. As of Spring, 1985, such a favorable student-to-computer ratio was available at only 7% of high schools and roughly 2% of elementary and 3% or middle schools in the country. A student in a typical computer-using elementary school spent only 20 minutes a week at a terminal in 1983, according to the study, and in 1985 the figure had risen to only 35 minutes a week. In the same period, the time high school students spent with the machines went from 45 to 90 minutes a week.

The ways students use computers differ sharply by grade level, as might be expected. Most elementary school educators said the machines were best used to improve basic skills, while most high school teachers said they were most valuable for learning about computers.

In high schools, the study found, only 10 percent of computer instruction time was allocated to problem-solving. The study said 49 percent was devoted to teaching programming, 20 percent to word processing, and 16 percent to drill and practice.

Across all school levels, about one-third of students' instructional time on school computers is for drill-and-practice and tutorial programs, one-third is for programming, and one-third is for all other academic work including "discovery learning" and word processing.

Preliminary findings also indicate that elementary schools which keep their computers in one or two locations use them roughly 10% more than do those that spread them among more locations. Further, the typical student working in a computer lab uses computers for about twice as much time as the typical computer user in a classroom, and at the middle school level, the difference is 3 to 1. This is partly because students doing programming use more computer time than students doing CAI, and more programming goes on in lab locations.

From kindergarten through the 8th grade, the most common use of computers is for enrichment. In addition, about one-third of computer time is for remediation. At the high school level, computer use most commonly occurs in a class <u>about</u> computers rather than a class using computers as an instructional medium or a productivity tool.

Demographic Differences

The study found that computer use differs substantially between boys and girls, although not everywhere and not in all respects. Overall use and word-processing, on the average, are activities where the participants are roughly equally divided among boys and girls. In addition, enrollments in elective programming classes in the middle and high schools in this sample were also roughly evenly split between male and female students, with the typical school reporting 45% female in these activities.

On the other hand, most computer-using schools report substantial male dominance in several other areas. In schools where the computer is used either before or after school, boys outnumber girls three to one. Boys also dominate elective programming activities in elementary school and game-playing in middle and high school. For most schools, girls are dominant only in high school word-processing, which is explained by the fact that most high school word processing occurs in business education courses where girls comprise most of the enrollment.

Teachers report that, for their students who are most affected by computer use, girls are more likely to be helped academically, while boys are more likely to be affected in terms of behavior and attitudes, such as improvement in self-confidence, self-discipline, or motivation.

Higher-ability students are also likely to dominate computer use. Compared to average students (those in the "middle-third" of their class), "top-third" students use computers more overall, more before- and after-school, more in word-processing, and much more in elective programming. Higher-ability students do not, however, dominate in the playing of computer games.

The most frequently reported effect of computers on lower-ability students is in improved motivation, self-confidence, and self-discipline. In contrast, teachers report that computers help higher-ability students primarily with higher-order thinking skills, programming skills, writing, science projects, out-of-school activities, career preparation, and real-world experience. Lower-ability students also receive academic help from their computer work but primarily for developing basic skills in math, reading, and language.

The type of community where a student lives affects access to computer time and affects how that student is likely to use computers. The study found that geographic location and socio-economic (SES) variables do not appear to have a significant effect on access of elementary students to computers, although an effect was found for secondary students. In particular, fewer computers are owned by low-SES middle schools, small town middle schools and senior high schools, and high schools in farming communities. Much lower percentages of these schools had 15 or more computers, compared to high-SES and large metropolitan high schools. While a smaller school also has a smaller number of students, and the ratio of students to computers may not differ from the ratio at larger or more urban schools, the report suggested that <u>15 computers per school</u> may be a minimum number for serving students in instructional groups, regardless of the student-to-computer ratio.

The level of expertise of computer teachers was another factor differenting among types of schools studied, at least at the secondary level. High-SES middle schools and high schools had teachers with more expertise than other middle and high schools, and high schools in farming communities are staffed by less expert computer-using teachers. Other communities have basically similar patterns of teacher computer expertise.

Perceptions of School Personnel

Across all school grades, schools with more computers reported more improvement in educational outcomes. Both principals and teachers listed two areas as most improved: student enthusiasm for the subjects for which they use computers and special opportunities for the academically gifted. In addition, the following outcomes were also seen:

* enthusiasm for school in general;
* special opportunities for learning disabled students;
* students working independently;
* students helping other students with their questions;
* learning in school subjects by below-average students.

Several differences in perceived effects were related to how computer time was allocated among possible uses. Middle and high schools that allocate more computer time to word-processing report more favorable outcomes generally. Allocation of computer time for programming and computer literacy is negatively correlated with perceived learning outcomes at all grade levels.

In this survey, the outcomes with the LEAST perceived improvement due to computers are

* individualization of assignments,
* diagnoses of individual learning difficulties, and
* learning in regular subjects by average and above-average students.

Some differences can be seen between elementary and secondary schools in this study in their perceptions of the best way to use computers, and these differences parallel differences in the way in which computers are actually being used at the two levels. A majority of elementary teachers believe that the best use of computers at their level is to apply them to students' mastery of basic reading and math skills. Middle and high school teachers believe that the best use of computers at their level is primarily for students to develop computer-related skills such as programming.

These opinions, however, appear to be evolving over time, with changes perhaps occurring in the elementary grades first. An increasing proportion of teachers at all levels are coming to believe that computers are best used as a tool to help students accomplish concrete tasks in writing, problem-solving, data analysis, and other areas. The report points out that a similar change in emphasis has been occurring in the professional literature on educational computing. They conclude that, while favoring "tool uses" was still a minority viewpoint among educators when this survey was conducted in 1985, this view appears to be increasing in popularity.

The vast majority of teachers report that their style of organizing classroom instruction and time for class preparation have not changed since they began using computers. Some changes are reported more frequently than others, however. High school teachers report more changes than middle-school teachers, who report more changes that elementary school teachers. The largest reported impact of computers on instructional practices is on mutual helping or peer-tutoring among students. Increases in class preparation time are also reported by 25% of the middle school teachers and by 37% of the high school teachers; below the high school level, however, computers cause increased preparation time mainly in classes with high-ability students.

To summarize the findings of the Becker Study which have been reported to date:

* In class, teachers are seeing less computer game-playing than in the past, and are finding computers' tool uses--such as with word processing, spread sheet and problem-solving software--more beneficial than expected.

* While teachers say it's obvious that computers make great student motivators in the classroom, they hesitate to say that computers are actually improving students' learning.

* Teachers and principals who view the learning benefits of computers most positively work in schools that emphasize word-processing activities or have high computer-to-student ratios.

* Computers' greatest positive effects on classroom social and instructional activities have been in student enthusiasm for subjects for which they use computers, special opportunities for the academically gifted, and more mutual help among students, particularly in the higher grades.

* Computers have brought little improvement to individualization of assignments, diagnoses of individual learning difficulties, or learning in regular subjects by average and above-average students.

* Some teachers say they're having to work harder to prepare for class sessions that use computers.

"The lack of impact of CAI may be due to the generally unsystematic way that schools have implemented CAI programs," according to the report. "Few schools have had enough computers to allow half or all of one teacher's class to use programs simultaneously."

"As of 1985, few schools used a sequence of programs that provided skill practice and instructional dialogue on the full range of objectives covered in a particular course. And few used instructional management systems to direct an individualized sequence of appropriate instruction by diagnosing each student's areas of instructional need," the report states.

Dr. Becker feels that the time has come for computer-using schools and school districts to objectively analyze just what kind of job computers are doing in their classrooms. The Johns Hopkins Center for Social Organization of Schools is looking for schools and school districts to participate in such a study, focusing on computer-assisted instruction in five subject areas at the upper-elementary and middle-school levels: mathematics, writing, earth science, social studies and reasoning and problem-solving skills. According to Dr. Becker, "Such evaluations should employ experimental designs, that is, both 'computer' and 'non-computer' approaches to teaching the same material, random assignment of students or classes to these alternative treatments, and post-tests equally appropriate to the instruction given by each method."

OTHER STUDIES OF SCHOOL COMPUTER USE

A small-scale study of teacher perceptions prepared by the Appalachia Educational Laboratory (AEL) obtained results which were similar to those in the Becker study. In the AEL survey, teachers responded to the AEL needs assessment and identified the most serious problems in instructional computing as:

* obtaining a sufficient number of computers for teacher and student use;
* lack of financial and logistical planning to integrate computers into school and classroom activities;
* access to information about software sources and to reviews of software;
* access to software simulations, tutorials and programs that address problem solving and higher-level skills;
* training in computer operations and instructional uses.

An in-depth observational study of a single school, beginning with the first purchase of computers and following student use and progress through the first year illustrates the difficulty in conceptualizing and implementing a good program (Trumbull, 1986). The author concluded that students found the novelty of computers to be motivating, but that the almost exclusive use of drill-and-practice software created a competitive atmosphere, contributed to passive learning and failed to provide students with a concept of computers as a tool. In interviews, students indicated that they felt a need to learn about computers because of their future importance, but had no concept of what computers would be used FOR.

EFFECTIVE CAI PROGRAMS

Writing to Read

An innovative computer-based reading and writing program was developed by IBM in 1980 for kindergarten and first-grade children. The program encourages children to listen to the 42 phonemes in the English language, to write those sounds, and then to put them together into words, sentences and stories. Student journals, recorded stories, and games are also part of this program. Implemented in 27 Writing to Read centers in the Washington, D.C. school beginning in 1982, the program has shown considerable success with low-income black children, as well as with middle class white students.

Writing to Read labs contain five learning stations. Children usually work in pairs for 15-minute sessions at one computer station where the phonemes are introduced by a voice-equipped IBM Pcjr. They then have time to work alone as they illustrate and write or type their stories, and then read their stories to one another. At the listening library station, they use tape recorders to match speech with written word. The program is self-paced to enable children to progress at speeds matching their individual abilities.

An evaluation of Writing to Read conducted by the Educational Testing Service (ETS) reported that, based on 6,000 writing samples, "Writing to Read children clearly surpass comparison students in writing performance. This appears to be true across both kindergarten and first grade...and across differing populations based on sex, race, and socio-economic status ("Nation's capital finds 'Roots' in Writing to Read," 1986)."

Mathematics

A recent study by the University of Oregon's Center for Advanced Technology in Education (CATE) has found that instruction supplemented with the use of microcomputers can help student learn math skills more quickly and cost-effectively than straight traditional instruction can. Over a period of 71 school days, just 10-11 minutes a day per student using the "Milliken Math Sequence" software produced impressive results with third- and fifth-graders at the test site in Saskatchewan. The student using computers scored significantly higher in math concepts and problem-solving at grades 3 and 5.

One of the few studies to examine cost in relation to the amount learned, it found microcomputer-aided instruction to be highly cost-effective despite its higher initial price tag when compared to traditional instruction alone. "In the third grade, the cost of providing each month of gain in CTBS [Canadian Test of Basic Skills] Total Mathematics was found to be $45.13 with traditional instruction and $26.81 with adjunct microcomputer-assisted instruction," according to the authors of the research report. To achieve a month of gain with a fifth-grader, they recorded a cost of $36.27 for traditional instruction and $22.53 with the help of a microcomputer. "The microcomputer instruction cost slightly more to deliver, but the gains in achievement were proportionally much greater and made up for the extra cost by a factor exceeding five in grade three and a factor exceeding six in grade five," the authors concluded.

For 10 minutes of daily microcomputer instruction in the classroom per student, the CATE researcher figured 24 cents for the third grade and 30 cents for the fifth grade. Per year, that comes to $37.63 for third-graders and $53.90 for fifth graders. The authors noted that, "given these low values, the cost of providing adjunct microcomputer-assisted instruction of the sort used in this study may be small enough to appeal to many school boards making implementation decisions."

The CATE researchers also compared this classroom-based use of microcomputers with costs estimated by studies of laboratory-based use. The annual per-student cost for 10 minutes daily in a microcomputer lab is $119-121. These higher figures can be attributed to higher site costs and staffing costs for using a lab instead of the classroom for instruction, and to the more sophisticated hardware used in the studies of lab-based CAI, according to the CATE researchers. They concluded that the lab approach would not result in personnel costs savings, although it might result in savings in hardware and software.

Their 45-page report, "Costs, Effects, and Utility of Microcomputer-assisted Instruction," provides cost tables that can help school districts plan for computer use. Copies of the report are available from Publications Sales, Center for Advanced Technology in Education, 1787 Agate St., Eugene, Oregon, 97403.

ISSUES IN IMPLEMENTATION

The Role of the Principal

A recent study of exemplary practices in Illinois elementary schools conducted by an Illinois principal (McGee, 1986) found that the role of the school principal was crucial in implementing an effective microcomputer curriculum. Specifically, the single most important funct[illegible] of the principal is direct, active involvement in scheduling; arranging inservices to train teachers; identifying and ordering good software, texts and resource materials; and creating work spaces or stations which make the computer a natural and comfortable part of the school environment.

A second important characteristic of principals in schools with exemplary programs was their willingness to reward or recognize teachers who promoted computer use. Principals who used a variety of means to acknowledge the efforts of teachers who used the computer were more likely to have successful programs in their schools than principals who let the staff's work go unnoticed.

McGee also studied teachers' perceptions of the problems surrounding computer implementation, and found that their most frequently cited obstacle was the lack of adequate software. In addition, teachers indicated that they often did not see what benefits the use of computers would have for their students.

McGee concluded that a CAI program is more [illegible]y to be successful if the building principal follows the [illegible]teps:

* identify specific problems and determine possible solutions;
* take an active role in scheduling computer use, arranging inservice training, acquiring resources, and establishing conditions favorable to computer implementation;
* purchase enough machines to have one for every two classes;
* acquire a small but adequate number of good, student-tested software programs;
* work to develop a positive attitude among the staff;
* use several means to encourage teachers to use computers;
* establish clear, operational goals;
* reward or recognize teachers who use computers in their classes.

Checklist for District Computer Use

In order to help districts to assess their CAI programs, a checklist for monitoring the instructional use of computers was developed by Merilyn Coe of the Northwest Regional Educational Laboratory. This checklist focuses on 5 key issues that must be addressed in order to implement an effective program. These include decisions about

* instructional use

* equipment, such as brands and funding

* inservice (Coe believes that "the relationship between equipment, curriculum development and successful implementation pivots on the issue of inservice.")

* equity and equal access

* guidelines for use

A copy of this checklist and supporting explanation is included as an Appendix to this report.

Providing Equal Access to Computers

The Becker Report documented some of the inequities that exist in the use of computers across various demographic categories or ability levels. The issue of identifying possible inequities is also addressed in the Checklist for Monitoring Instructional Use of Computers, in the Appendix. Additional circumstances which may also lead to inequities in computer use were studied by the American Institutes for Research (DuBois & Schubert, 1986), who identified several unintentional results of administrative actions.

* Establishing irrelevant prerequisites to computer learning, for example, reading at grade level, high math GPA, or quick finishing of in-class work. The authors point out that such policies exclude the poor reader, the math-phobic student, or the detail-oriented worker, and that prerequisites for computer use must be defensible.
* Placing computers in inappropriate areas, limiting or precluding access to some students. In some schools, every class has one computer; without proper training for teachers, this policy can produce rates of computer use varying from 0 to 100% of the time in different classrooms. In one school studied by DuBois & Schubert, all the computers were in one math classroom, with the result that only one teacher and his students used them.

* Accepting common assumptions about equitable computer learning. Administrators, teachers, and parents in

this study were often found to accept computers as part of the male domain and attribute a lack of involvement on the part of females or other groups to disinterest when, in fact, the opportunity is not there or the activity is uninteresting.

The authors, research scientists at the Center for Educational Equity, recommend the following sources for addressing issues of equity in computer use:

<u>IDEAS for Equitable Computer Learning</u>, available from the Center for Educational Equity, American Institutes for Research, Box 1113, Palo Alto, CA 94302

[The Center for Educational Equity is the Title IV Sex Desegregation Center for Arizona, California, and Nevada, and also offers staff development training in computer equity, as do many of the Title IV centers for other areas.]

<u>The Neuter Computer: Why and How to Encourage Computer Equity for Girls</u> from Computer Equity Training Project, Women's Action Alliance, 370 Lexington Avenue, New York, NY 10017

<u>Programming Equity into Computer Education</u>, a kit available from PEER, 1413 K Street, N.W., Washington, DC 20005

Additional suggestions aimed specifically at narrowing the gender gap were also offered by McKenzie & Demarest (1986):

* Teachers should be informed regarding equity issues, and encouraged to examine the role models and computer use opportunities they offer to girls.

* Information should be provided to elementary students regarding the career implications of computer illiteracy in a technological society.

* Schools should consider using programs that are less "gender-divisive"; LOGO is recommended over BASIC, and word-processing should be as fully supported as programming.

* Parents should be encouraged to support home computer use by daughters as well as sons.

* Parents should be made aware of the disadvantages of computer games and poorly-designed drill-and-practice packages which tend to reward aggression and may appeal primarily to boys.

* Schools should encourage mothers as well as fathers to help educate their children in computer use and provide suggestions for parents in ways to reverse the trend of male dominance in computer use.

FUTURE TRENDS IN CAI

In a review of issues surrounding "computer literacy", Alan Lesgold (1986) suggests that the key to surviving major technological change, such as the increased prominence of computers in society, is having the skills to use the new technology to extend one's capability.

The implications for school curriculum include the need for more complex schooling, good verbal and graphic communication skills, and the ability to formally characterize and solve problems. While specific technological knowledge is needed in a computerized society, the specific facts and skills acquired today will be less important tomorrow. Thus, the curriculum must teach children to learn new information and skills efficiently.

Because software specifically developed for educational applications is in its infancy, Lesgold recommends the increased use of word-processing, spreadsheet, and graphics programs, all of which are well developed, readily available, and cost-effective. The use of word-processing software was discussed in the previous CAI report; Lesgold also suggests that spelling checkers and software which assists students in developing outlines from their ideas can be very helpful. In his own research, he has found that a spreadsheet program can be useful in science courses in which children conduct experiments, in which they manipulate variables and measure their effect. The students keep the data in matrix form with the spreadsheet program, and can examine and manipulate the numbers in a systematic fashion.

Lesgold also points out that the simple, low-level programming courses taught in schools today will not help students in the workplace. Based on programs and systems already becoming available, it is clear that in the future, routine programming will be done automatically by the computers themselves. Consequently, if programming is to be taught in schools, it must be for purposes other than vocational training, specifically in order to put the computer to work for oneself. Thus, the outcome of programming exercises should probably be software that students will use later as tools in another course. What is critical is not the exact program content but its usefulness to the student, and this provides a better rationale for computer use in the first place.

Some similar predictions for computing's effects on education have emerged from a recent article published in the Association for Computing Machinery's book Topics in Computer Education: National Educational Computer Policy Alternatives. Other articles included in this book cover such areas as evaluating educational programs, planning strategies, contemplating ethics and answering the need for more research. Among the predictions are the following:

* The necessity of dealing constantly with new computer technology and ideas will lighten the educational system's "oppressively static nature."

* Computers will be used not only to teach and improve materials and methods from the past, but to create totally new educational directions.

* Being able to "navigate information" will replace learning of a given set of facts as the mark of an educated person.

* The computer's ability to provide "immediate gratification" for right answers may lead the educational system to emphasize topics that can be easily reinforced by computers.

* Graphics will rise to equal prominence with text as a way to "represent, understand and manipulate" processes and ideas.

* The view of "product" as all-important will give way to a greater focus on "process." The very nature of computers will force us to examine our way of "writing, programming and even thinking."

The book is available from ACM Order Dept., P.O. Box 64145, Baltimore, MD 21264.

SUMMARY

The major points that emerge from recent literature support those that were made in the original CAI literature review.

The Becker study found that most American schools have computers, but relatively few schools make the most advantageous use of them. Principals and teachers interviewed for the study perceive that the use of computers enhances student motivation, cooperation and independence. Computerized instruction also was said to help lower-achieving students master basic skills and to provide new challenges for high-ability students.

However, the high expectations held for CAI have not been fulfilled for average students, for diagnosing specific instructional needs, for systematic individualization of instruction or for improving most learning of facts and concepts, the study concluded.

When surveyed, teachers continue to cite too few computers, too little information about software, too little training, and too little planning for integration as the major blocks to good CAI programs. Suggestions were offered in the body of this report to assist principals in overcoming these obstacles.

Increased time with the computer appears to be useful for students, an issue which is related to the number and placement of computers in school and their accessibility to all students. The Becker study reports that most students only spend a few minutes a week using a computer, and suggests that 15 computers per school, in a lab-type setting where all or most of a class can be accommodated at once, may be put forth as a minimum need. However, the previous report also indicated the importance of ready access for students to solve specific problems, without time lost to a trip to the computer lab, suggesting a need for a computer in each classroom.

Also important is the committment of the teacher to encouraging students to use a classroom computer. Teacher knowledge and attitudes remain critical to the success of any CAI program, underscoring the need for well-designed inservice.

The issue of access also refers to equitability across students of different ability levels, gender, SES and other characteristics. Suggestions were offered in the body of this report for assessing inequality of access in a school district and for remedying inequalities that are found.

Viewing the computer as tool rather than focusing instruction on programming and on the computer itself is an important trend in the field as a whole which is beginning to be reflected in the schools. Word-processing can be useful for almost every student, while programming languages are probably best seen as electives, and when taught, should produce programs which the student can then use in other classes.

The way in which students spend their educational computer time is also important. Some drill-and-practice can be useful, but the evidence supports trying to increase time spent on simulations and problem-solving.

It is too early, however, to draw conclusions regarding the effects of CAI on learning. Research has not yet focussed on the relevant variables such as type of CAI employed, appropriateness to subject and student, teacher training and effectiveness. CAI is a method of presenting instruction and practice, not a separate "teaching technique".

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APPENDIX

DISTRICT COMPUTER CONCERNS:
Checklist for Monitoring Instructional Use of Computers

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DISTRICT COMPUTER CONCERNS

CHECKLIST FOR MONITORING INSTRUCTIONAL USE OF COMPUTERS

This packet of materials will be useful to those involved with planning, organizing and implementing computer use in schools. This packet can be applied (1) to assess the present state of instructional computer use in the district, (2) to assist with the development of plans or guidelines for computer use, (3) to support a start-up phase, and (4) to monitor the implementation or progress of an on-going program. Careful monitoring of current practice is essential if decision-makers are to understand and appreciate the instructional use of computers.

This packet is organized around key issues for decision-making about computer use programs. Any useful computer plan, guideline, or policy will need to address these key issues. This checklist is designed from the district's perspective and based on the need for coherency, rationality and coordination between buildings and districts.

MAIN AREAS

1) How is a computer to be used? (CAI, word processing, programming) What hardware and software are currently used?

2) Cost - What can be budgeted? Who is paying?

3) Inservice training - who, what area, compensation?

4) Equity - What are the patterns or present use? Is equal access assured?

5) Computer use plan - Is there one? Is it implemented?

I. Decision About Use

Within instructional use, there are three categories: (1) computer assisted instruction (CAI), (2) computer programming, (3) software application. The questions on the following page are based on this categorization. Please add any other uses that occur in your district in this space.

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Check each of the following curriculum areas if computers are now being used and will in 2 years be used on a regularly scheduled basis: Use one of the following marks for magnitude: 0, /, or / /. 0 = none, / = some, / / = lots.

	Elementary		Middle/Jr.		High	
	Now	In 2 Yrs	Now	In 2 Yrs	Now	In 2 Yrs
1.1 CAI: Are there classes using CAI?	____	____	____	____	____	____
1.2 Programming: Are there classes in:						
Programming - BASIC	____	____	____	____	____	____
Programming - PASCAL	____	____	____	____	____	____
Programming - LOGO	____	____	____	____	____	____
Programming - Other	____	____	____	____	____	____
Software Applications (W/P)	____	____	____	____	____	____
Other Computer Literacy	____	____	____	____	____	____
1.3 Integrated Usage: Is computer applied software being used to supplement classes and texts in:						
Business Education	____	____	____	____	____	____
Composition	____	____	____	____	____	____
Reading	____	____	____	____	____	____
Language Arts	____	____	____	____	____	____
Journalism	____	____	____	____	____	____
Foreign Language	____	____	____	____	____	____
Mathematics	____	____	____	____	____	____
Science	____	____	____	____	____	____
Social Science	____	____	____	____	____	____
Health	____	____	____	____	____	____
Career Education	____	____	____	____	____	____
Library Skills	____	____	____	____	____	____
Agriculture & Forestry	____	____	____	____	____	____
Drafting	____	____	____	____	____	____
Electronics	____	____	____	____	____	____
Industrial Arts	____	____	____	____	____	____
Home Economics	____	____	____	____	____	____
Music	____	____	____	____	____	____
Art	____	____	____	____	____	____
Physical Education	____	____	____	____	____	____
Keyboarding - typing	____	____	____	____	____	____

	Elementary		Middle/Jr.		High	
	Now	Needed: in 2 Yrs	Now	Needed: in 2 Yrs	Now	Needed: in 2 Yrs
1.4 Audiences Served: Are computers being used in programs for						
Education/Handicapped	____	____	____	____	____	____
Education/Gifted	____	____	____	____	____	____
Career Information System	____	____	____	____	____	____
Teachers	____	____	____	____	____	____
Other	____	____	____	____	____	____

1.5 Time on the Terminal: Provide rough estimates (or percent) of average student time per activity, even if subsumed within another course.

	Level		
Activity	Elementary	Middle/Jr. High	High School
Total weekly time spent in:			
Drill and practice	____	____	____
Tutorial	____	____	____
Simulation	____	____	____
Instructional games	____	____	____
Other instructional tasks	____	____	____
Recreational games	____	____	____
Library	____	____	____
Utilities	____	____	____
Computer application instruction (learn about word processing)	____	____	____
Computer application for other subject matter instruction	____	____	____
Communications	____	____	____
Computer programming	____	____	____
Other	____	____	____

1.6 Requirements: What computer courses or competencies are/will be required in:

	Elementary School	Middle/Jr. High School	High School
Now	____	____	____
	____	____	____
	____	____	____
In 2 years	____	____	____
	____	____	____
	____	____	____

1.7 Extent of Usage: What percentage of students are actually using these stations and will be using them in 2 years:

	Percent Now	Percent in 2 Years
Elementary	______	______
Middle/Jr. High	______	______
High School	______	______

II. Decisions About Equipment: Brands and Funding.

2.1 Computer Types: List the number and brands of computer hardware this district has at the following levels:

	Level		
Terminals	Elementary	Middle/Jr. High	High School
Apple II's	______	______	______
Apple Macintosh	______	______	______
Commodore 64	______	______	______
Radio Shack color-computer	______	______	______
Radio Shack I, III, 4	______	______	______
IBM PC	______	______	______
IBM PC Jr.	______	______	______
Acorn	______	______	______
Texas Instruments	______	______	______
Apple II Compatible	______	______	______
IBM Compatible	______	______	______
Other	______	______	______

2.2 Special Provisions: Maintenance....security....room space....student carrels--any other special site provisions (wiring), lighting, air conditioning)—any special provisions for staff (computer room personnel, computer coordinators at building or district levels).

2.3 Students/Terminals: What is the ratio of number of students to work stations?

	# of Schools	# of Students	Stations	Ratio
Elementary	____	____	____	____
Middle/Jr. High	____	____	____	____
High School	____	____	____	____

2.4 Distribution of Hardware: Where are the student stations located in the school? How many are

	Elementary	Middle/Jr. High	High School
in classrooms	____	____	____
in library/media centers	____	____	____
in "computer room"	____	____	____
mobile "floaters"	____	____	____
other	____	____	____

2.5 Funding Sources: What percent of funding for hardware and software came from:

	Percent
Federal Funds - Chapter 1, Title I	____
Federal Funds - Chapter 2	____
Other Federal Funds	____
Private Foundations	____
State Funds	____
Business/Industry Donations	____
District Funds	____
School Funds	____
Parent-Teacher Associations	____
Other Funding	____

2.6 Other Sources: What current budgets are being used for the computer program?

____ Library Media Fund

____ Textbook Adaption Fund

____ Discretionary Building Fund

____ Computer Program Funds

____ Other

2.7 Allocation of Funds: What percent of these funds is allocated to:

		Percent
Hardware:	New purchases	______
	Replacement	______
	Maintenance	______
Software:	New purchases	______
	Replacement	______
	Maintenance	______
Training		______
Staff		______

2.8 Purchasing Policies: Decisions for obtaining:

Hardware: Uniform supplies

Bid

Other

Software: Consortium (e.g, Oregon Ed. Computer Consortium)

Vendor: Mail order/Retail

Other

2.9 Insurance: Does your district have separate insurance for your computer hardware and/or software? Y/N ________ If yes, does it cover the following:

	Y/N
Theft	_____
Fire	_____
Vandalism	_____
Off-site uses	_____
Liability	_____
Other	_____

2.10 Is there a designated district computer coordinator: Y/N ______

If yes, what budgeted FTE is provided for this position? ____ FTE

To whom (position) does the district computer coordinator report?

____

2.11 Name a school that exemplifies the most successful pattern of computer adoption.

____

2.12 District Variability:

Very wide _____ Somewhat _____ Uniform _____

III Decisions About Inservice. Inservice is the key to successful program implementation. Staff commitment and training is essential for "cadre' model" adapted by most schools. In this model a few teachers are trained and are responsible for training other teachers. The question of setting priorities may be addressed by a few (e.g., steering committee), some, or many (e.g., total staff). A priority may be that many students have a small amount of computer time, or a few students having a lot of time. A district must identify what criteria will be used to determine which students will use the computer and for what reasons. The relationship between equipment, curriculum development, and successful implementation pivots on the issue of inservice.

3.1 Does your district provide classes in any of the following:

Ares of Inservice Training	Y/N
Introductory Computer class (10 hr.)	____
Basic Programming (30 hr.)	____
Software Review (25 hr.), how to select software	____
Integrating Software in Classroom Activities (20 hr.)	____
Application of Different Software (45 hr.) Indepth knowledge of: electronic spreadsheets, data base management, word processing, grade books, test development	____
Authoring CAI (30 hr.), basic principles of instructional scftware design	____
Information Retrieval course (25 hrs), utilization of major national data base, such as those of the New York Times, SOURCE, or Career Information System	____

3.2 Over the last 12 months, what computer-related topics have been covered by:

District-Sponsored Inservice Programs

Building-Sponsored Inservice Programs

3.3 What percent of your teachers have now completed some inservice training for instructional computing and will have in 2 years? Inservice training in this question refers to training that has taken at least a day to deliver.

	Now	In 2 Years
Elementary School	______	______
Middle/Jr. High	______	______
High School	______	______

3.4 How is inservice preparation for computer uses provided? Of all inservice thus far provided, (about) what percent comes from:

Source	Percent
District Resource Person	______
Training/Tuition Reimbursement	______
District-Sponsored Inservice Training	______
School-Sponsored Inservice Training	______
Building-Level Resource Person	______
Individual Initiative	______

3.5 What percent of your instructional computing inservice training is provided by:

	Percent
District Computer Coordinators	______
School Computer Coordinators	______
Classroom Teachers	______
School Administrators	______
District Administrators	______
Other District Staff	______
Educational District Staff	______
College/University Faculty/Staff	______
Commercial Providers	______
Other Non-District Personnel	______

3.6 What percent of your teachers have taken instructional computing inservice training at the following times:

	Percent
After school	______
Release time	______
Weekends	______
Summer school	______

3.7 What is the average amount of time (during last school year) a teacher spent on instructional computing inservice training?

____

3.8 What incentives or compensations are provided for development of computer capabilities by teachers, resource people, and/or administrators?

3.9 Which building has utilized a particularly effective training program?

IV Decision on Equity. Equity is defined as accessibility - by whom and when.

4.1 When are student stations (or computer lab) available?

All day = 8 hours every school day Y/N ____________

Other arrangement ________________________________

4.2 Is there a prerequisite for access? Y/N _________

If yes, indicate which of the following is a prerequisite:

GPA	______
Class standing	______
Class enrollment	______
Study hall	______
Computer License*	______
Job (office attendancd)	______

* Some districts have a voluntary introductory program on computer use; completion and certification (license) is required before a student can use a computer.

4.3 In classes that consistently use computers, what percent of enrollment are boys and girls?

	% Boys	% Girls
Computer Classes (Computer I, II, III, Computer Applications)	______	______
Mathematics	______	______
Business Classes	______	______
English Composition	______	______

4.4 What techniques have been attempted to address the problem of differential utilization?

4.5 Which ones have been successful?

4.6 How is the hardware distributed?

_____ Equal number to each building

_____ Based on enrollment proportions

_____ Designated by steering committee

_____ Other

4.7 Is there a scheduling procedure? Y/N _______
Please provide a description of how it is organized.*

* Many districts have reported that scheduling is a key element: "maintaining a scheduling system that allows for the greatest possible use is our main challenge."

V <u>Guidelines - Plan</u>. Successful use of computers to assist learning will not occur without careful planning. A plan should include guidelines on: objectives of computer use, curriculum areas, equipment (hardware and software) selection and evaluation, facilities plan, staff training, equity and resources. A steering committee is useful and should be a representative group who have a commitment to computers, willing to work on learning strategies and evaluations. They will be charged with identifying the criteria which determine which students will use the computer and for what reasons.

5.1 In planning for instructional computer use, does the district use

	Y/N
District Administrative Use Committee	____
District Instructional Use Committee	____
Combination of the Above	____
Community Committee	____
Secondary Committee	____
Elementary Committee	____
Principals' Committee	____
Teachers' Committee	____
Administrator and Key Staff	____
Administrator	____
Individual Staff Members	____
Ad Hoc Committee	____

5.2 Does the district have written guidelines for instructional uses of computers?

Y/N ______

If yes, does it address:	Y/N
Hardware Purchasing	____
Software Purchainsg	____
Hardware Evaluation	____
Software Evaluation	____
Maintenance Requirements	____
Inventory Control	____
Required/Desired Teacher Competencies	____
Required/Desired Administrator Competencies	____
Required/Desired Student Competencies	____
Community/Home Coordination	____
Provisions for Staff Development	____
Personnel Requirements	____
Funding Sources	____
Space and Site Preparation	____
Copyright Protection	____
Information Security or Protection	____
Incentives for Individual Development	____
Incentives for School Development	____
Plans for Growth for next 2-3 years	____
Plans for Growth for next 4-6 years	____
Plans for Growth for next 7+ years	____
Curricular Use	____
Extra Curricular Use	____
A method for easily identifying computer-related expenditures	____

5.3 Are all these guidelines being followed? Y/N ______
If no, which are not being followed:

5.4 How do you rate the following possible problems as impediments to plan development and implementation of instructional computing in your district?

	Minor	Moderate	Major
Financial constraints	____	____	____
Cost of Staff Development	____	____	____
Lack of Staff Incentives	____	____	____
Software: Poor Quality	____	____	____
Hardware: Lack of Power	____	____	____
Absence of District Plans	____	____	____
Inappropriateness of District Plans	____	____	____
Inappropriate School-Level Plans	____	____	____
Administrator Attitudes	____	____	____
School Board Attitudes	____	____	____
Teacher Attitudes	____	____	____
Student Attitudes	____	____	____
Parent Attitudes	____	____	____
Community Attitudes	____	____	____
Lack of Physical Space	____	____	____
Administrator Competencies	____	____	____
Teacher Competencies	____	____	____
Student Competencies	____	____	____
(Others???)			

5.5 Of the possible impediments listed in the above questions, which three present the most difficult problem?

most difficult:

next most difficult:

third most difficult:

5.6 Is there an impediment not listed that you feel should be in the top three?

COMPUTERS IN EDUCATION

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ADMINISTRATIVE SUMMARY

The purpose of this review is to give a general outline of the major issues regarding the use of computers in education. Most assuredly this is a large topic and probably too large for a paper. Decisions have to be made about what to include and what to exclude. The major issues selected are definitions, computer usage, achievement gains, staff development, and finally, trends.

Computer-assisted instruction (CAI) has experienced significant growth with the accompanying growth of computers in society at large. A variety of uses for CAI and a plethora of vocabulary and terms have resulted. Investigation of CAI indicates that students may benefit from CAI as a method for becoming familiar with computers and reducing computer anxiety. This in turn would help open doors for later learning and employment. A backward chain seems to drive the need for computer familiarity. Employers often require computer skills of job applicants. Many colleges expect high schools to send them computer literate students. High schools are beginning to expect ninth graders to come in with basic computer skills, and elementary schools are struggling to determine what computer programs should be.

A variety of students benefit from CAI. Computers afford individualized learning that can be patient, infinitely repetitive and motivational. In fact, there is "something for everyone," with computer applications for every segment of the student population. This ranges from the opportunity for directing the computer to the provision of special services of speech synthesis, high-speed Braille terminals, communications boards and fine-motor training equipment for handicapped learners. Low ability students benefit from the structure and opportunity for diverse rehearsals that computers can provide. Teachers bring a variety of skills and adaptations to CAI that benefit a variety of students. Teachers may use a computer as an "electronic chalkboard." Teacher time may be reduced and charting of student progress streamlined. Finally, the National Council for Teachers of Mathematics highly recommends CAI for all students.

No definitive optimum figures have been determined for how much time students should receive CAI. However, research does indicate the direction that more computer access is better than less. While students can benefit from cooperative learning, large group instruction is not as effective as small group CAI under teacher supervision.

Reported achievement gains vary from study to study but in math, spelling and other language arts, CAI produced equivalent or greater achievement that traditional instruction. In addition, CAI reduced learning time and resulted in improved student attitudes toward computers.

With regard to writing, students tend to write more often, enjoy writing more, generate longer essays and make more revisions when CAI is used. When comparing writing with a word processor to writing by hand, results are inconsistent. However, when more interactive programs are used and when two senses are stimulated simultaneously via word processing and voice synthesis, results are more positive for CAI.

A final concern for CAI is the preparation of faculty. While more and more states are mandating some form of computer literacy and even beginning to require computer training in certification requirements, a significant challenge to an integrated CAI program remains the staff development of inservice teachers. Principles of effective staff development include the presentation of a rationale for new learning, the provision of a model and sufficient rehearsal to gain control of new skills, and the delivery of coaching and substantive feedback for teachers engaged in learning new instructional behavior.

The trend of CAI for the future is in the upward direction. Local control is a common feature of state computer mandates, accompanied by new emphasis on computer use. Another trend involves the establishment of positions for state computer coordinators in state boards of education to promote computer use in education. More computers, better and more interactive software and better prepared teachers are the pictures on the horizon for CAI.

INTRODUCTION

In the years between 1965 nd 1980, the use of computer assisted instruction has increased twenty-fold (Ascher, 1984), but the field of computer assisted instruction (CAI) is still new enough the it remains less than concretely defined. CAI is very individualized within school districts and under the direction of different teachers for different purposes. While CAI may connote meanings such as tutorial instruction, the term may be used to apply to any use of computers for learning and, thus, includes a number of subsets under its umbrella. Computer-managed instruction refers to employing the computer as a record-keeping device and does not provide learners with any direct instruction. Computer-based interactive instruction includes two instructional strategies: tutorial instruction and drill-and-practice. Tutorial instruction refers to a method for introducing new material to the student. With this method, the computer poses a question for the learner, analyzes the learner's response, provides appropriate feedback, and presents new material to fit the demonstrated needs of the student. Drill-and-practice is used to mean a computer-based method for rehearsal of already known information via questions and feedback to the student's responses.

Computer-based instructional simulation is an instructional method in which a situation that imitates a real life experience is presented to the learner. Then the computer program poses a problem within the situation and the student makes decisions. The student's reponse results in the presentation of a new situation to the student. This use of computers asks students to analyze, integrate, synthesize, evaluate and solve problems (Encyclopedia of Educational Research, 1982). Computer literacy may be defined as whatever a person needs to know and do with computers in order to function competently in our information-based society (Lockheed, et. al., 1983). Skills, knowledge and understanding are the three competencies. The term skills refers to abilities to use and instruct computers to aid in management, learning and solving problems. Knowledge is used to mean knowledge of the functions, applications, limitations, capacities and social implications of computers. Understanding refers to that cognitive recognition necessary to learning and evaluating new technologies or social implications as they arise (Lockheed, 1983).

Problem solving refers to story problems in any subject area designed to develop logical thinking patterns in the users by encouraging logical steps in approaching problems and by providing feedback for steps taken (Berry & Berry, 1984). Gaming simply means playing games that are designed for the computer. Some games are interactive, some are simulations, still other are drill-and-practice in nature.

Computer-assisted instruction may include a few, several or all of the kinds of instruction defined here. The type of CAI to use and its role in general education is decided locally in individual districts. In fact, Reinhold and Corkett (1985) report that while a number of states require some form of computer education, the most common form of state-level involvement is support for district programs. Over half the states (26) have some form of computer literacy requirements for students and 36 of the states have a state computer coordinator in the state board of education to promote computer education. A look at some district or school programs and the trends seen in CAI will follow.

WHY?

An important consideration is that of motivation. Why should educators consider CAI at all? One reason is certainly the need to function competently in our information-based society (Lockheed, et al., 1983). There is also the top-down effect of the school hierarchy. Employees demand computer skills of job applicants, colleges demand skills in their students, and this drives secondary school to provide instruction. Elementary schools look to high schools for direction.

The literature helps to a limited degree in providing this direction. One study by Kulik, Bangert, and Williams (1983) used a meta-analysis to integrate findings from 51 independent studies on computer-based teaching with students in sixth through twelfth grades. The cumulative findings from Kulik, et al. indicated that students' final exam scores rose from a mean of the 50th percentile to a mean of the 63rd percentile in a variety of subject areas from math to science. Computer-based instruction also resulted in small gains on follow-up evaluations conducted several months after instruction was completed. Students who were taught with computers developed positive attitudes toward computers and the courses for which computers were used, while computers simultaneously reduced the amount of time necessary for learning.

Of the included studies, those that were more recent and of shorter duration tended to yield higher effect sizes. This suggests that gains produced by CAI do not accelerate at a constant rate. Nevertheless, CAI results in maintenance of both computer skills and subject area knowledge as evidenced by improved achievement scores of students who received CAI.

While CAI may positively influence achievement, it should also be noted that the findings of another meta analysis (Kulik, Kulik, & Bangert-Downs, 1984) indicate that the most positive results of computer-based teaching were found at the elementary level. CAI produced much greater achievement than computer-managed instruction. Low ability students appeared to experience the greatest effects. The Kulik, et al. findings also identified a decreasing effect size as grade level increases. They theorize that learners in lower grades benefit from highly structured instruction and a reactive teaching medium while older students need less structure, feedback and teacher control.

Another benefit of CAI for both young students and low ability or special education students is the capacity for individualization. Boettcher (1983) lists several characteristics of computers that make them perfect for individualization:

1. Provide a secure, one-to-one learning environment.
2. Truly individualized.
3. Demand responses and thereby decisions.
4. Provide prompt immediate feedback.
5. Type in responses, helps with reversals, etc.
6. Provide decision points.
7. Model linguistic or mathematical behavior.
8. Provide multisensory learning experience.

Dorsey and Burleson (1982) cite several reasons to teach with and about computers. The first is to avoid looking "like a fool" and to function competently. The second involves principles of operation, that is, better opportunities and better pay exist for those with computer skills and without computer fear. Also, computers provide growth in decision-making logic afforded by computer instruction involving problem solving and simulation. Finally, computer-aided management may be the wave of the future for even mundane concerns such as grocery shopping and vacation planning.

Howe (1981) states that the computer from the child's point of view can be a familiar exciting device which can solve some very difficult problems. Its motivational aspect is derived from the fact that the computer is untiring, predictable, never angry and even obedient (Severo, 1984). Computers exhibit these characteristics that people lack but determine to be valuable when teaching slow learners (How, 1981). Finally, CAI has resulted in improved behavior and attendance on days when CAI was scheduled (Kimko, 1985). Behavior-related improvements are powerful reasons for teachers to use CAI.

WHO?

Research on microcomputers in schools suggests that the gaps between poor and rich and between talented and underachieving students may be widening. One survey's results should that 66 percent of affluent school districts have computers while only 41 percent of the least wealthy districts have them (Ascher, 1984). Another difference noted was that wealthy students are trained to program, that is, they tell the computer what to do. Poorer students use the computer for drill-and-practice in which the computer tells them what to do (Ascher, 1984; Paul, 1983).

Ragosta (1982) notes the increased prevalence of computers in secondary schools over elementary schools. However, computers may be more useful in elementary school years to allow for individualization and immediate feedback. Uses for computers are multiplying rapidly. Virtually every segment of the school population can benefit. Talking calculators, high-speed braille-terminals and Kurzwell readers that synthesize speech from print are used with visually impaired students (Walker, 1980). Kay (1977) emphasizes the role of computers for children in the arts. Children can use computers to create cartoons, compose music, or write stories. Zinn (1978) points out the visually attractive finished copy of word processing as a plus for young learners.

Walker (1980) reports on studies using CAI for Spanish-speaking children that improve self-concepts and for black college woman that remediate deficiencies in language arts and math and provide computer literacy. He also discusses uses of computer for hearing impaired students. Computers allow students to rehearse visual memory skills, learn speech reading skills and gain controlled speech aid. Robertson (1978) studied 36 third grade students who were the poorest spellers in their grades. Students who were frustrated with failure in the classroom responded positively to the challenge of CAI presented on teletype terminals.

Mentally and physically handicapped students benefit from the individualization. In addition, computer use offers a significant variety of drill-and-practice programs for the same concept (Walker, 1980). This is important when it may take years of drill for mentally handicapped students to master the addition facts. A variety of drills staves off boredom while allowing for sufficient rehearsal to master concepts. Physically disabled students are accomodated by voice synthesizers, communication boards, and fine motor training equipment. The computer can be used to specifically match the needs of handicapped children and their families with services, agencies, and information most appropriate to their needs.

Teachers may use computers to help with more than instruction. Colbourn (1982) suggests the role of computers in diagnosing learning disabilities. A system guides the user through diagnostic steps, suggesting alternatives after each new piece of information is provided.

Schulz (1979) reports that teachers adapt differently to computer innovations. She states that teachers use computers to store data on skills acquisition, to report test results, to group students for skill instruction, and to report other summary data. The focus of the study was on improving reading achievement and enhancing teaching. Some teachers added CAI to traditional instruction. Others substituted CAI for traditional instruction. Still others revamped the curriculum to accomodate CAI components. All teachers, regardless of their strategy for incorporating CAI, benefitted from establishing rapport and sharing complaints, successes, and questions. The teachers collaborated to devise a solution to a school concern, met educational goals more efficiently and were stimulated to progressive development by the cooperative project.

Teachers may also use the computer on a large television screen or monitor as an "electronic chalkboard" (Tamashiro, 1983). The advantages include overcoming of teacher concerns about handwriting; reduction of chalk dust; neat, clear, authoritative appearance in visual presentation; and the ability to save information without relying on little notes on the blackboard and the observant behavior of district maintenance personnel. Tamashiro does not intend this group viewing of the screen to replace individual use but rather adds it as another management tool.

An investigation of teacher characteristics and computer use demonstrated that all teachers have the potential for using CAI effectively. Morris (1985) conducted a study of 173 public elementary schools in Florida, dividing the schools into three groups: 1) those with no instructional microcomputers; 2) those who had computers and offered programming courses; and 3) those who had computers but did not offer courses in programming. Faculty characteristics did not correlate significantly with student achievement. If no faculty characteristics correlate with student achievement in most cases, it is reasonable to theorize that teachers with a variety of characteristics may successfully use CAI. In other words, there are not just a select few teachers who, by merit of some personal characteristics, can use CAI and improve student learning.

The National Council for Teachers of Mathematics (Walker, 198) suggests the following among its recommended goals for math instruction:

1. Take full advantage of calculators and computer at all grade levels

2. Use flexible curriculum options for all students.

3. Provide math instruction for all students and design it to meet diverse needs.

4. Provide more emphasis on computer-related skills such as problem solving than on computer facility.

HOW MUCH?

Roblyer and King (1983) reviewed several reading studies and noted that smaller computer-based classes result in significantly greater achievement than larger classes. Researchers in the 1970's had theorized a reduction in the teaching force as a result of computers (Norris, 1979). Roblyer and King's research, however, supports the idea that computers enhance but do not replace teachers' abilities.

Bell (1986) reports that two students sharing a terminal often spontaneously results in communication and exchange of knowledge. Students cooperated to share experiences, confer on problems and questions and justify answers to each other. This suggests that a computer for every two students may be a powerful enhancer of learning. Learning that is cooperative, rather than competitive or individualistic (that is, one individual competing against all the other students for a grade on a curve), produced significantly greater achievement (Johnson, et al., 1984). Having computers readily available for students to access as needed may have the effect of learning French in France (Papert, 1980). Communication with computers becomes a natural process when immersion is possible.

The Alberta Department of Education (1983) recommends a minimum of 15 - 30 minutes per day of computer time in spelling alone for each child after studying the effects of computer use for spelling in an experimental/control group design study.

While a number of researchers have conducted studies on the effects of CAI, most of the studies have centered on the question of whether CAI is as effective or more effective as traditional instruction in a variety of subject areas. Few researchers have reached conclusions about the optimum time of computer use as a result of these studies. The literature shows no definite answer to this question. However, Komoski (1984) cautions that however much time is spent, the key issues are the quality of the software selected and the way the software is used in the curriculum. The sensible caution reminds readers to consider quality more critically than quantity. The presence of CAI has not altered the focus on quality for instruction of any kind.

An important trend for schools shows that states are beginning to pass mandates regarding computer education (Reinhold and Corkett, 1985). The following chart shows the varying state requirements as of 1985.

REQUIRING A COMPUTER LITERACY COURSE

Louisiana New Hampshire New York Rhode Island

South Dakota Tennessee Texas Utah Wisconsin

REQUIRING SCHOOLS TO INTEGRATE COMPUTERS INTO THE CURRICULUM

Arkansas District of Columbia Vermont

REQUIRING SCHOOLS TO OFFER AN OPTIONAL COMPUTER COURSE FOR STUDENTS

Minnesota Nebraska Nevada Pennsylvania

Washington

THAT MANDATE COMPETENCY, OPPORTUNITY, OR STANDARDS, BUT DISTRICTS DECIDE IMPLEMENTION (INTEGRATION OR COURSE)

Delaware Florida Hawaii Indiana Maine

New Mexico North Carolina Oregon Virginia

REQUIRING ALL TEACHERS TO TAKE COMPUTER COURSES FOR CERTIFICATION

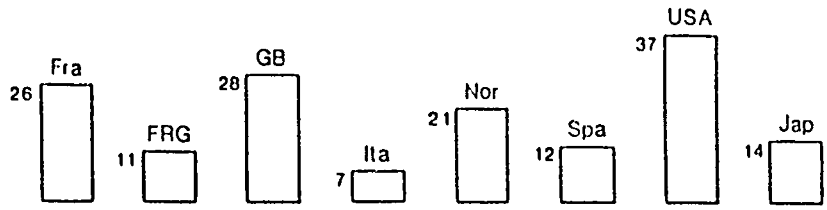
District of Columbia Texas Utah

REQUIRING SOME TEACHERS TO TAKE COMPUTER COURSES FOR CERTIFICATION

Illinois Kansas Montana New Hampshire

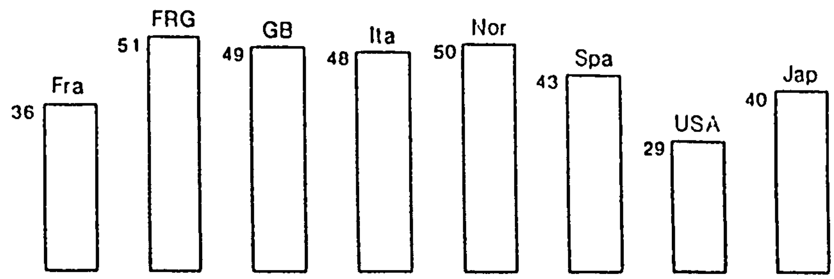
New Jersey Oklahoma Oregon Vermont Washington

From an international perspective, a study by Frey (1986) of eight countries showed that the most computer experience was in the United States. It was estimated that thirty-seven percent of the American population had used a computer or a word processing system. The percentage is distinctly lower in the European countries and even a "computer country" such as Japan had a percentage of 14%.



I have already used a computer or a word processor.

Frey concludes that less computer experience does not appear to be the result of limited availability and shows the percent of his sample agreeing to the statement "I have not used one and am not interested either."



I have never used one and I am not interested either.

ACHIEVEMENT GAINS

Most of the studies conducted with regard to CAI examine the results of instruction, that is, the achievement gains of the students. Many researchers admit that there is not enough empirical data yet regarding the variety of CAI uses. This is especially true in the areas of problem solving and critical thinking skills (Roblyer, 1985). A brief review of some of the results of these studies allows a reader to get a sense of trends of CAI use and results.

Young Children

Bower (1985) reports that six-year olds who programmed a Apple II computer in two 40 minute sessions a week for 12 weeks showed improved scores on two types of thinking tests, a creativity test and a test in which the student must identify when there is not enough information to solve a problem. Students receiving computer-based arithmetic and reading instruction did not show the same improvement. These differences did not, however, result in differing scores on other instruments also used to assess the thinking of the 18 children in the study.

Language Arts

Edeburn and Jacobi (1984) relate that a year cf using microcomputers to improve reading and language skills of 72 limited-English-proficient Native American students resulted in gains in achievement. While for 51 percent of the students, scores on the Comprehensive Test of Basic Skills improved by three or more Normal Curve Equivalents, problems in record keeping make it difficult to determine what portion of achievement gains was directly due to the use of computers in instruction. Edeburn and Jacobi attributed a degree of the academic improvement to the use of CAI.

Murphy (1984) investigated whether CAI was more efficient and whether it concomitantly produced increased self-esteem and attitude toward academic learning. The findings were that vocabulary and spelling areas were related to increased gains and these gains were accompanied by an increase in self-esteem. Another finding was that computer time ordinarily allotted may be insufficient for special learners; they work at a slower rate and may need longer sessions in order to demonstate consistent gains.

Caster (1982) reviews 16 research studies evaluating CAI effectiveness in teaching language arts and reading. The studies were based on drill-and-practice tutoring uses of computers. CAI was found to be more effective than traditional methods for teaching reading, vocabulary and language. Findings for the effectiveness of CAI for writing and spelling were mixed. Long term gain for CAI groups persisted. Eight studies investigated student attitudes and seven of the eight studies indicated that students enjoyed computers while on found no change in student attitude.

Some current software limits the potential for interaction between computer and student. Rubin and Bruce (1984) report, after examining 317 language arts programs, that 60 percent were of the drill-and-practice type. As a result, they developed and offer QUILL which helps children learn to take notes, write down ideas and structure thoughts; enter text, assign key words and peer edit; format text for publications; support meaningful communication with real audiences; write with and for peers; and spell and punctuate correctly and use appropriate subject-verb agreement.

The results of these studies suggest that CAI may be used to improve language arts skills, free teachers and students for concentration on different tasks, improve self-esteem and allow for success for special education or slower students. Software may be an enhancement to a CAI language arts program or a detriment. In order to help districts and teachers evaluate software, Caissey (1984) suggests questions that help delimit teacher needs, questions that guide teachers to important issues of quality in instructional design and questions that help teachers to review other aspects of software that may effect the success of CAI.

Mathematics

CAI in math skills helped elementary school children improve math achievement (McConnell, 1983). Approximately 500 students in grades 3 - 6 were assigned to three groups: 1) CAI; 2) the paper and pencil drill-and-practice equivalent; 3) the regular district math program. CAI was significantly more effective than the other two treatments for improving computational and total math scores. CAI appeared to be most effective for third grades and least effective for sixth graders but the match between CAI and standardized test items may have been poorer at the upper grade levels. CAI was effective for migrant children, children with limited English proficiency and children enrolled in remedial or special education. A positive correlation between time spent on the computer and gain in math performance was demonstrated. That is, the students who had more computer access achieved greater gains in math achievement than those with less computer access, even when the total time spent on math remained equivalent. Also a high and consistent correlation existed between grade equivalent scores on standardized tests and the computer ratings of the same students.

Dorsey and Burleson (1982) report on the results of a Big Lake, TX study of 500 K - 6 school children in which microcomputers were used to assist students with math. Originally, teachers were not involved in the project, but teacher aides were taught to operate the computers. Results at the end of one year show marked improvement in math (from 1 year 8 months to 2 years 1 month growth) and in reading (from 1 year 7 months to 2 years 1 month growth) scores in one year. During the first year, 300 teachers received training in the use of the computer as an educational tool. Problems in the project which were determined to influence the potential for even more improvement included limited machine locations, short computer time (15 minutes per week) for students, and a lack of dedicated space for computer based instruction.

Campbell, et al. (1985) conducted a study of two groups of 24 third graders practicing division problems. Each group practiced 30 minutes per day with one group using CAI drill-and-practice and the other group using traditional print drill. Results were comparable. This suggests that drill-and-practice uses alone do not make CAI more effective than other methods of instruction.

In reviewing the results of these studies on math achievement and the study that investigated both math and reading achievement, a significant finding was the relationship between time spent at the computer and achievement, indicating increased access correlates positively with greater achievement. Another important observation was that CAI must be used for more than drill-and-practice to realize the potential of CAI to positively influence achievement. Finally, teacher aides are human resource that may effectively be used with CAI. Researchers theorize, based on studies of the computer as an educational tool, that when computers are easily accessed and students have daily CAI time, achievement can be significantly improved. In general, Roblyer (1985), after reviewing dozens of studies, reports that math areas seem to profit more from computer-based instruction than reading/language arts areas. This statement is even more powerful when it is remembered that many CAI efforts have been successful in reading/language arts.

Spelling

Spelling may lend itself particularly to computer-managed instruction through some recent technological breakthroughs. Traditionally, spelling instruction has been a labor-intensive process of making word lists to fit individual learner's needs or the inefficient process of having each student learn identical words. However, speech synthesis and economical mass storage data may alter this state of affairs. Thomas and Gustafson (1983) describe a study involving 163 third and fourth grade students from an upper middle class suburban school. Software selected and spoke the words for each student. Subjects in the machine group (91.8% mean) scored significantly better than the control group (87.3% mean). Once students learn to use the computer, teacher and paraprofessional time is estimated at 140 hours per day as opposed to, 430 hours per year of teacher time on the lists program.

English, Gerber and Semmel (1985) state the microcomputer assessment is an attractive adjunct for teachers because it allows for "repeated, accurate, and individually paced measurement" with very little cost in teacher time. Gerber (1984) found that the use of pre-testing, self-correction and post-testing was the most consistently effective single technique for improving spelling achievement. Robertson (1978) reports that students improved in spelling skills regardless of whether meaningful or nonmeaningful words were used. The important factor was calling students' attention to the detail of a sequence of letters.

Hasselbring and Crossland (1982) report that the Test of Written Spelling can be effectively administered by a computer with 2.0 minutes of teacher time used per administration. This is in contrast to 12.6 minutes of teacher time required to administer the Test of Written Spelling in the traditional format. The computer was also found to be more accurate in scoring than were the human examiners. The learning disabled students in the study claimed to prefer typing instead of writing and to like to work with the machines. Seeing the words in the same print in which they studied them was very helpful to spotting errors.

The Alberta Department of Education (1983) effectively used CAI to teach spelling and sentence dictation. Pupils using CAI completed more lists of words and scored significantly higher than control groups. Students themselves handled the scheduling and machine set-up. All pupils became proficient at the use of computers.

Peer tutoring and teacher help were successfully used to make up work that students missed while at the computer. A by-product of this study was that growth in writing skills was also noted.

Cautions regarding spelling and the use of computers are:

1. While computers allow students to "pace themselves", this may result in more opportunities for distraction than with teacher-directed instruction (Varnhagen, 1984).

2. Students may allocate time and attention to computer operation instead of to learning and content (Gerber, 1984).

3. Time spent on searching for a key results in more key strokes and actually more time spent in learning for learning handicapped students (English, et al., 1985).

CAI and its use with spelling instruction has positive achievement gains to recommend it. But the research indicates that certain types and aspects of CAI spelling instruction are more successful than others. Using the computer to manage individualized spelling lists, to synthesize speech and allow for auditory and visual rehearsal of spelling words simultaneously, and to reduce teacher time expended in instruction is most effective. Teachers are still the crucial variable in CAI. Students still must be encouraged to remain on task and to answer questions that facilitate learning rather than have them frustrated with regard to either content or computer operation.

Word Processing and Student Writing

Many educational researchers and practitioners believe that the use of computers as classroom tools in the area of writing will have a tremendous impact on the composing process and on children's development of writing skills (Hennings, 1981; Schwartz, 1982; Watt, 1983; Bridwell, Nancarrow and Ross, 1984). Since, with the help of computers, one can take any piece of text apart, reword it, restructure it, and rearrange it, writers can take more risks and be more tentative about their thoughts. In the course of doing this, a great deal can be learned about language and the writing process (Newman, 1984).

Teachers often report that children are reluctant to write and unwilling to edit or revise their work. Writing involves both the mental processes of composing and the physical process of producing the text. Since word processors can alleviate the demands of the physical aspects of writing, it is believed that more energy can be devoted to the cognitive processes, with improved performance as a result (Watt, 1983). In addition, composing at the computer can reduce fear to making a mistake and foster a willingness to do more experimenting with words, sentences, and paragraphs. For writing with poor handwriting and spelling ability, self-confidence can be increased when writing is done with a word processor (Schwartz, 1982).

Anecdotal Reports

Much of the published information regarding the effects of composing on a word processor has been in the form of anecdotal reports. Teachers and researchers (Barber, 1982; Fisher, 1983; Branan, 184; Jacoby, 1984) who have observed children composing at the computer remark that pupils: 1) begin to enjoy writing, 2) write more often, 3) stay on task longer, 4) produce longer compositions, 5) respond more favorably to criticism, 6) correct spelling and punctuation errors more often, 7) make more revisions at the word, sentence, and paragraph level and 8) develop an increased understanding of how written language works.

Students report that they like writing at the computer because it's easier to correct mistakes, papers don't become messy from corrections, and parts of an essay, such as the introduction, can be written at any time and inserted as desired (Fisher, 1983).

Midian Kurland, a research associate at the Bank Street School's Center for Children and Technology notes that children write more when using computers even when they can't type well. He believes the students attach more importance to their writing on the computer than when writing in the traditional way (Suttles, 1983).

At the Bank Street College of Education, Kane (1983) worked with a group of 8th graders in a 10-session minicourse in writing with a computer. Her observations of the students showed that they: 1) spent more time on a given assignment when using the computer; 2) were intensively involved with the composing process; 3) felt free to explore their ideas; and 4) revised more than when they wrote by hand.

Research Findings

Very little actual research regarding the effects of composing with a word processor on childrens' writing performance exists at this time. The research conclusions presented in this section are the result of library work and phone contact with various researchers across the country. Since this is such a new area of investigation, some of the results cited here are yet to be published.

There is little empirical research evidence of the effects of computer-assisted composing. In studies which compared the use of a word processor to writing by hand, the results are inconsistent. (Johnson, Schnieder and Stone, 1985; Duling, 1985; Daiute, 1985a; 1985b). Several of the studies showed either no differences between papers written by hand and those generated on the computer, or differences in favor of hand-written compositions. Other studies, however, did report results in favor of computer-assisted writing. In studies where students using a word processing plus computer prompts designed to improve their writing were compared to students not using a computer, the majority of the findings showed that the computer users revised more and/or wrote better compositions than the pupils who composed by hand. (Woodruff, Bereiter, Scarda Malia, 1981-1982; Daiute, 1983, 1985b; Bruce and Rubin, 1984).

While it appears as though the use of a word processor plus a computer program designed to prompt students to interact with their text is beneficial, more studies of this type would be helpful. More research is also needed to determine whether or not merely giving students access to a word processor is sufficient to improve writing performance.

CAI-RELATED ISSUES

Cost

Levin (1984) designed an appropriate cost methodology for computer cost-effectiveness and then reviewed CAI cost effectiveness. This cost effectiveness data was derived via a formula that accounted for hardware, a secure facility for housing computers, curriculum software, knowledgeable personnel, provisions for maintenance, and other support materials. Ingredients were valued in annual terms. The results indicate that computer hardware does not account for most of the cost of CAI, declines in future costs of computers will not necessarily reduce the cost of CAI, and network microcomputers used for CAI are not less costly than minicomputers with equal capabilities. In terms of raising student achievement in math and science, CAI was more cost-effective than reducing class size, lengthening the school day or providing adult tutoring. CAI, however, was less cost-effective than peer tutoring.

Multiple Uses

In addition to traditional CAI uses, there are a number of community uses for computers purchased for classroom use. This is important to districts that desire to use acquisitions efficiently. Community uses include adult education classes, parent education courses, student computer club use and extending the school day with after-school activities. Computers have been used successfully for adult basic education as well (Paul, 1983).

Bell (1986) reports that the learning center is the most efficient model that research generated. Terminals are grouped in assigned rooms under the supervision of an administrator. The most successful plan established learning centers that were not restricted to the traditional school year and could remain open on weekends and the evenings.

Staff Development

As with other educational technology predictions in the past, one of the speculations about CAI was that instruction could become teacher-less. In fact, Norris (1979) predicted that technology would enable education to become less labor-intensive and more capital-intensive, dramatically reducing the costs of education. Three reviews investigated the effects of replacing teachers with CAI (Edwards, et al., 1975; Glass, 1982; Kulik et al., 1983). Glass and Edwards especially found that supplemental use of CAI was more effective than supplanting the teacher with CAI. Kulik found that whether the use of CAI was replacement or supplemental did not significantly affect achievement. While computers do not spell teacherless instruction, computers can significantly improve the capability of teachers to deliver effective instruction (Robyler, 1985).

For teachers to use CAI to supplement other kinds of instruction, they must have knowledge of computers and be trained in the functions and uses of the computer for instruction. Only 12 states have computer certification requirements for teacher candidates (Reinhold & Corkett, 1985). The most realistic approach, then, for putting new knowledge in the hands of millions of practicing teachers is through staff development programs.

Findings of studies such as Morris' (1985) research indicate that faculty variables do not make appreciable contributions to student achievement after accounting for variables measuring aspects of student ethnicity and community wealth. This is good news in the sense that is indicates that staff development has the potential to make the difference via improving instruction without having to overcome the effect of teacher characteristics. Another way to think about that is to say that all teachers have the potential to benefit from staff development in CAI.

However, in about half of elementary and secondary schools, only one or two teachers, at most, are regular users. This indicates a special need for staff development if computers are to be used most effectively. Methods include consulting by professional staff or outside experts, department meetings and demonstrations, workshops, summer curriculum development teams, paid released time, staff development within school systems, membership paid in professional organizations, travel paid to professional meetings, and university classes (Milner, 1980). Ragosta, et al. (1982) report that teachers who received inservice training on computers, terminals and CAI had positive feelings about bringing their classes to CAI labs on their own.

Finally, while CAI has been demonstrated repeatedly to have the greatest effect on elementary learners (Roblyer, 1985), teachers in the elementary school are least likely to have the necessary training (Miller & Voelker, 1984), but future teachers are more likely to have had computer training of sometype. A report based on 428 colleges and universities randomly selected with a response rate of 96% in May of 1984 by Douglas Wright (Report on Education Research, 1986), showed that 90 percent of schools surveyed offered some form of computer training. About 20,000 microcomputers were available for education students in 1983-84 with an average of 26 for each school of education offering a computer course. Introductory computer courses were the most popular during undergraduate work and instructional use of the computer was the most popular type of course at the graduate level.

For teachers not enrolled in formal courses, the need for constructive staff development in computer education becomes obvious if a school district is committed to promoting the use of computers in its eductional program.

Recent research in staff development and inservice teacher education (Moffitt, 1963; Harrison, 1980; Joslyn, 1980; Joyce and Showers, 1983; Carroll, 1985) had indicated clear directions for the characteristics of effective staff development. These points can be generalized to staff development in computer education.

1. Staff development must be ongoing. Single session presentations have little lasting effect.

2. Staff development should use group and individual problem-solving.

3. Initiation of a staff development program should be made by a school district, that is, locally.

4. Participants working toward mutually established goals appear to improve more than those who work toward goals established for them.

5. Programs are more effective when a combination of approaches (individual and group, active and receptive) is used.

6. Follow-up support improves outcomes.

7. Programs working toward cognitive goals showed the greatest effect size for groups of 31 - 60 teachers.

8. Staff development programs are more effective when highly structured in format and when concrete objectives are related to specific subject matter.

9. Inservice programs are effective when offered during or after school hours, and Saturday training sessions are not as effective.

10. Programs using individual supervision are effective alternatives to traditional group sessions.

11. Staff development programs should plan for transfer of training to actual teaching settings, use principles of overlearning, provide for executive control of new knowledge, and allow for practice in the real work situation as soon as possible.

Programs should include:

* study of the theoretical background or rationale for the teaching method
* observations of expert models who demonstrate the teaching techniques
* the opportunity for practice and feedback in a supportive environment
* the provision of coaching, companionship and feedback

Current and Future Trends

The researcher doing the most definitive studies on the use and distribution of computers in the United States in education is probably Henry Jay Becker. From the results of 10,000 questionnaires and telephone interviews with about 2,100 principals and teachers representing over 2,100 schools, Becker (1986) found that eighty-six percent of U.S. schools had at least one computer. The typical elementary school had about six, middle and junior high schools had fourteen, and senior high schools had twenty-one, about four times the number in the same schools just two years earlier.

A typical student uses a computer 50 minutes a week, but the time per student varies widely. The time also varies widely by males and females. For example, there is a great deal of male dominance in special computer use such as before-and-after school activities, game playing and in elective programming activities. The only area where females dominate is in word-processing in high school. Computers are used more often with special student populations than with regular classes, and more with the top and bottom achievement groups than the middle range groups. In elementary schools, more than half of the time is spent on "drill-and-practice" and "tutorial" programs and only about one-eight of the time on students writing computer programs. High schools differ in that only sixteen percent of the time is used for computer-assisted-instruction and half of the time is spent on programming activities. Becker summarizes that about one-third of school computer time is for "CAI," one-third is for programming and about one third includes all other instructional activity.

Trends from Becker in staff involvement showed that about one-fourth of U.S. teachers use computers with their students, with a much higher proportion of elementary teachers than others. Achievement is affected by computer use, but Becker cautions that he is exploring the relationship of teacher expertise to the use of computers. Also, race, socio-economic status, and achievement all differentiate schools in their ownership and use of computers, and a great deal of variation exists in computer use among schools of the same basic demographic makeup.

Computers are and will be used in a variety of subject areas so that the start up costs, especially in terms of staff development time, training in use and operation of computers for students, and purchase of hardware and software, are cost effective.

Computers are becoming management tools. Students need teachers more, rather than less, to direct timing, provide motivation, maintain task-oriented behavior, and interpret skills, needs and outcomes. CAI is most effective in small groups under teacher direction (Roblyer & King, 1983). The caution for CAI use with spelling, and undoubtedly in other areas as well, is that in self-directed activities, students have a great opportunity for distraction. With teacher supervision, this opportunity is reduced and more on-task behavior with greater potential for learning occurs.

Increased time at the computer for each student is indicated. Though no optimal time has been established, studies investigating time factors indicate that directions toward more computer time and access show the greatest effect on achievement. The suggestion of one computer for every two or three students has been made. While this is one of the more extreme positions, Watt (1983) has suggested that this ratio would provide optimal access for students.

Specific allocation of space for computer-based instruction is common and the maintenance of a number of accessible sites for machine location is increasing. Students benefit from scheduled, structured computer time. They can also benefit from ready access to computers to solve specific problems as they arise. In addition, time lost in non-instructional activity is reduced when the class does not have to take a five-minute trip to the computer lab.

With CAI, as with traditional test administration, one sample of behavior may be insufficient to measure student outcomes. This caution arises after reviewing a number of studies in which student progress was evaluated with a single sample of behavior from each student. If a greater breadth of student outcomes is to be observed, student behavior must be sampled in more than one way on more than one occasion.

When determining the effect of CAI versus traditional instruction, insufficient attention has been given to the variable of teacher effectiveness. Future research and evaluation of CAI programs may also benefit from an effort to measure and account for the quality of human instruction, that is, the variety in teaching abilities and effectiveness.

Directions for current use are moving away from automated programmed instruction with frames of multiple-choice questions and a drill-and-practice emphasis toward artificial intelligence and individually generative CAI and programs for problem solving where incorrect answers are explained.

"Expert" systems in which computers provide expert advice are also available. Geologists and medical diagnosticians as well as teachers are able to use information from thousands of cases rather than their own limited number of experiences (Colbourn, 1982).

The CAI coordinators from a four-year program in Los Angeles collaborated to produce the following advice about successful CAI use:

1. Have a very organized schedule and keep to it.

2. Maintain a positive attitude toward CAI and convey it to students and other staff members.

3. Establish and enforce fair standards of behavior, including good habits of equipment care.

4. Use interesting motivational aids. (CAI, after all, is instruction, and principles of good instruction apply to CAI.)

5. Maintain frequent effective communication among all participants in CAI.

6. Remember to allot time for hardware tasks. Frequent checking and maintenance reduces the potential for larger problems later.

Paul (1983) cites additional factors that contribute to CAI success:

1. Computer availability to students; frequent access is better.

2. Preparation of teachers; comprehensive continuous staff development is necessary.

3. Number of times CAI substituted for less beneficial activities.

4. Percentage of computer time spent on simulations, problem-solving and educational gaming; the higher the better.

Local control of computer education and CAI use, usually at the district level, is the most common pattern, with districts determining "the kind of computer education appropriate to the needs of that district" (Reinhold & Corkett, 1985).

Suggestions or future computer research are convincingly made by Salamon and Gardner (1986). They recommend:

1. Avoiding the question of whether CAI teaches better than other media.

2. Using holistic as well as experimental design research paradigms.

3. Remembering that learners bring a variety of assumptions, talents, and active learning strategies to CAI which affect the results of CAI.

4. Noting that there are unanticipated posi outcomes and a range of usages and experiences result of employing CAI.

These cautions may direct future research and evaluation of CAI programs.

Larger gains with computer treatments have been obtained at elementary levels than at higher levels (Roblyer, 1985). Greater use of computers could therefore be concentrated at the elementary school level rather than at the higher grade levels as is currently the case.

Most current reviews indicate better results for achievement in more recently published studies owing to improved software and more sophisticated instructional uses. Studies using regular CAI for students in contrast to more unstructured "computer enrichment" activities demonstrated better results (Roblyer, 1985).

In summary, the range of the trends is toward more computer availability, more interactive use, more CAI at the elementary level and emphasis on teacher involvement. Teachers need to be trained and continuously informed. Finally, computers must be accessible in location.

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