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Computer assisted instruction in the elementary school

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Abstract

Computers as we know them today had their infancy in the late 1940's. Since that time computer technology and its concomitant applications in everyday life have expanded at nearly geometric proportions. Today the technology is advanced to about the same state that black and white television had reached in the late 1950's. Concurrent to the early development of the computer were two major trends in education: an awareness among educators for the need of individualized instruction and renewed interest in programmed learning. Thus a natural confluence of a budding technology and educational objectives occurred, resulting in computer assisted instruction. Introduction of the computer into the classroom has not always yielded many of the expected benefits; however, technological advancements such as the microcomputer hold new promise for educators. If we are to fully benefit from the use of the computer we must understand the successes and failures of past computer assisted instruction efforts. Ultimately, the successful use of computers in education will hinge on the development of appropriate computer curriculum.

COMPUTER ASSISTED INSTRUCTION
IN THE ELEMENTARY SCHOOL

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INTRODUCTION

Computers as we know them today had their infancy in the late 1940's. Since that time computer technology and its concomitant applications in everyday life have expanded at nearly geometric proportions. Today the technology is advanced to about the same state that black and white television had reached in the late 1950's. Concurrent to the early development of the computer were two major trends in education: an awareness among educators for the need of individualized instruction and renewed interest in programmed learning. Thus a natural confluence of a budding technology and educational objectives occurred, resulting in computer assisted instruction. Introduction of the computer into the classroom has not always yielded many of the expected benefits; however, technological advancements such as the microcomputer hold new promise for educators. If we are to fully benefit from the use of the computer we must understand the successes and failures of past computer assisted instruction efforts. Ultimately, the successful use of computers in education will hinge on the development of appropriate computer curriculum.

Statement of the Problem

Probably the single most significant technological advancement of the twentieth century is the computer. This amazing machine has mind-boggling capacities. It performs tedious, time-consuming operations at the speed of light. Its speed would enable a large computer to do the following tasks in the half second it would take a cup of coffee to fall from a table to the floor.

> "(1) Debit 2000 checks to 300 different bank accounts, and
> (2) examine the electrocardiograms of 100 patients and alert a physician to possible trouble, and
> (3) score 150,000 answers on 3000 examinations and evaluate the effectiveness of the questions, and
> (4) figure the payroll for a company with a thousand employees, and a few other chores."
> (Baker, 1975, p.34)

In addition to its great speed the computer has extraordinary communication potential. It puts all the communication technologies together; it can talk, show complicated graphics, and respond to input. (Brandt, 1981, p.61) The computer can make decisions and alter its own programming according to external stimulus. The fact that this is an unique and singularly amazing machine with capabilities readily adaptable to education is apparent.

The purpose of this study is to examine: the major characteristics of computer assisted instruction; the historical development of the computer and its relationship to computer assisted instruction; the implementation of computer assisted instruction in the elementary school; the curriculum development of computer assisted instruction materials; the advantages and disadvantages of computer assisted instruction; and the future of computer assisted instruction.

Importance of the Problem

Educators have before them the most prodigious educational machine technology can offer. At the same time educators are attempting to cope with the individual needs of students more than ever before. There are unprecedented efforts being made in trying to accommodate the needs of the learning disabled, the gifted, and the remedial student. Coincident to these events is the advent of reduced funds for education and increased instructional responsibility.

The fact that we have 50 million children with divergent abilities, experiences, interests, and learning styles coupled with higher educational expectations is inescapable. The ideal situation of 50 million teachers for 50 million children is economically and socially unrealistic. The essence of the computer is its universality and its power to stimulate. It can take a thousand forms and can serve a thousand functions. (Nelson and Friedman, 1981, p. 11) The computer may not solve all our problems but it does offer the potential to solve many of our education problems.

Definition of Terms

1. Computer: An electronic device capable of processing information by following a set of directions. This device can read directions and retrieve data from a modifiable memory.

2. Bit: Smallest possible unit of computer information storage.

3. Byte: A group of 8 bits processed as a unit; smallest unit of information that can be worked upon from memory.

4. K: Represents 1024 (2^{10}) bytes of information.

5. Memory: A part of the computer where data and instructions can be read back, retrieved, or modified.

6. CRT: Cathode Ray Tube, a display that is similar to a television set. This type of display requires a tremendous amount of computer memory as it requires refreshing 30 to 60 times a second.

7. Plasma Display Terminal: A display similar to the CRT but requiring much less computer power. This display does not require constant refreshing.

8. Timesharing: The simultaneous use of a single computer by more than one individual. This term is used relative to large and medium-sized computers.

9. Teletype: A type of computer terminal where interaction with the computer takes place through print medium rather than electronic display.

10. Program: A list of instructions in computer language which cause the processor to carry out specific tasks.

11. Microprocessor: A microcomputer's brain; each large scale integrated circuit contains memory, logic, control, and diagnostic elements.

12. Hardware: Typically the computer, terminals, disc reader, and other tangible physical elements.

13. Software: Common term referring to pre-programmed materials developed to instruct a computer to carry out specific tasks.

14. Large-Sized Computer: A computer of at least 8 million bytes of memory such as an IBM370.

15. Medium-Sized Computer: A computer of at least 1 million to 8 million bytes; such as an IBM3431.

16. Small or Mini-Sized Computer: Any machine less than 1

million bytes of memory.

17. Microcomputer: Differentiated from large, medium, and small computers by its microprocessor chip and software support.

18. Floppy Disc: An advanced long term memory device on which all the entries of a large dictionary could be stored and retrieved almost instantly; looks like 45 r.p.m. record.

19. CAI: Computer Assisted Instruction; common education use of computers.

Chapter 2

REVIEW OF LITERATURE

The literature review will be organized into six parts: (1) major characteristics of CAI; (2) the historical development of the computer and its relationship to CAI; (3) the implementation of CAI in the elementary school; (4) the development of elementary CAI curriculum; (5) the advantages and disadvantages of elementary school CAI; and (6) the future of CAI in the elementary school. Together these parts of the the literature review will examine computer assisted instruction in the elementary school.

Characteristics of Computer Assisted Instruction

There are a multitude of characteristics which make computer assisted instruction appealing to the educator. CAI is much more than its name or a tautological definition might imply. The educational opportunities offered by CAI are no less amazing and significant than the computer itself. One of the most appealing characteristics of CAI is individualizing of instruction.

> "Computer instruction can and does provide an almost endless amount of individualized instruction to the student. Each student works at his own computer terminal, doing his own work at his own rate. The computer can stimulate learning that would otherwise be boring....
>
> A typical CAI program will present the student with information in a programmed instruction format. The programs are constructed in a fashion similar to the

> branching programmed textbook. Because of the inherent capabilities of the computer many more variables can be taken into account. This meets the needs of a broader range of students making more effective use of individualized instruction. Computer techniques allow for "open-ended" responses, allowing for a large number of possible replies and branching possibilities. The advantages of speed with CAI allow for the instantaneous validation of student replies from the computer." (Perry, 1979, p.172)

It should be noted that this individualization is typically limited to a student's interests and pace, while individual learning style has been largely ignored. (Martin, 1981, p.43) However, researchers are finding the computer to be an excellent tool for externalizing a student's learning style and this too may someday be part and parcel of standard CAI individualization. (Martin, 1981, p.43)

Another appealing facet of CAI is the constant interaction between student and the computer medium. This interaction demands active participation from the student throughout the learning process. In carefully conceived CAI the student's senses of hearing, sight, and touch are frequently stimulated by the computer. (Perry, 1979, p.174)

Equally appealing are the advantages of each of the classifications or types of CAI. Computer assisted instruction includes the following four categories: one, Tutorial CAI; two, Drill and Practice CAI; three, Simulation or Modeling CAI; and four, Gaming CAI. (Florida State, 1980, p.4) Tutorial CAI is personalized instruction; it is often seen as an alternative to a lecture, film, or reading assignment. (Florida State, 1980, p.5) Drill and Practice CAI is an activity which provides a student with a series of practice items on material which has been previously learned. These lessons are particularly useful in their facility for providing immediate feedback. Immediate feedback is particularly advantageous in that it prevents the practicing and learning of error. (Florida State, 1980, p.5) Simulation or Modeling CAI is an activity which is designed to represent the salient structure or behavior of a real system. The simulations are used to give the student an opportunity to experience something which they would otherwise be unable to experience due to considerations of time, expense, or safety. Simulation CAI allows a student to make and test theories about the system being modeled. (Florida State, 1980, p.5) Gaming CAI, in an instructional context, pertains to games designed to practice skills through motivational activities. These games may be used as a reward or as a device to promote learning in a particular area. (Florida State, 1980, p.5)

As there are different forms of CAI curriculum, there are different forms of CAI computer systems. These systems generally include the following four categories: one, Large Timesharing Systems; two, Medium and Small Timesharing Systems; three, Standalone Microcomputer Systems; and four, Time Sharing Standalone Microcomputer Systems. (Florida State, 1980, p.7) The Large Timesharing Systems employ a large centralized computer which may be used by a number of users at any one time. The physical equipment includes a large number of CRT, teletype, or plasma terminals. These terminals may be located in close vicinity of the large computer or at remote locations. When the terminals are located at some distance from the computer a modem and phone line is used to span the distance. This arrangement allows a computer to be many miles away from its terminal. The Small and Medium Timesharing Systems are similar to the large timesharing systems. The difference between these systems is that the small/medium timesharing system cannot handle as many terminal users as the large system. The Standalone Microcomputer System is as the name implies a system which is entirely self-contained. That is, both the input/output terminal and microprocessor share the same physical location. In this system the individual user has complete autonomy over how and when a request will be handled. Time Sharing/ Standalone Microcomputer Systems use the microcomputer as a temporary terminal. The user first accesses the program he wishes to use from the large mainframe computer and then loads the program into the microcomputer. The user then severs his connection to the large computer and simply allows the microcomputer to run the program as a self-contained unit. (Florida State, 1980, p.7)

The Historical Development of the Computer and Its Relationship to CAI

In order to understand the development of CAI, it is necessary to understand the historical development of the computer. The development and implementation of CAI in our elementary schools is very much a function of the technological development of the computer.

Before entering into a description of the historical relationship between CAI and computer technology, it would be advisable to examine the features and advantages of a computer. The present day computer, the slide rule, and electronic calculators possess the following basic ingredients:

1. Input-Information entered by the user.
2. Processing-Mathematical operation or logical function carried out by the device.
3. Out-put-Information provided to the user. (Souvincy, 1980, p.54)

The distinction between the computer and these other devices is that the computer can be programmed to automatically make decisions. These decisions frequently reach a level of sophistication which result in the computer automatically altering its own program. (Souvincy, 1980, p.55) Computers offer three unique and powerful kinds of capability. The first of these capabilities is speed. A computer task such as retrieving a student's file from storage would be described in nanoseconds (one thousandth of a millionth of a second). The second of these capabilities is storage. Computer technologists suggest that in a few years it will be possible to store the entire contents of a university library on a one inch computer chip.(Florida State, 1980, p.1) The third of these capabilities is control. The computer can be programmed to control a large number of educationally oriented electronic devices, such as film and slide projectors, cassette tape recorders, phonographs, CRT displays, and countless others.

In 1944, the first automatic digital computer, the Harvard-IBM Mark 1, was built. This computer was electromechanical. The first electronic digital computer, ENIAC (Electronic Numerical Integrator and Computer), was completed in 1946. The mere description of the computer is awesome:

> "ENIAC was an enormous machine: 100 feet long, 10 feet high, and 3 feet deep. it contained 18,000 vacuum tubes, 70,000 resistors, 10,000 capacitors, and 6,000 switches. It was programmed by plugboards wired from the outside of the computer. The arithemetic system was performed in base 10 rather than base 2. An addition or subtraction with 10-digit numbers took 1/5000 of a second; multiplication, 3/1000 of a second; division 3/100 of a second."
> (Baker, 1975, p.15)

The year 1954 witnessed the introduction of the world's first commercially available computer, Remington Rand's UNIVAC, and the revival of the education concept of automatic self-instruction. Dr. B. F. Skinner's first teaching machines employed a program appearing on a tape in the window of a mechanical machine. These machines presented a sentence or two of information, a question (stimulus) on that information, the student's answer (response) written on the tape, and an immediate reply to that answer (correct/incorrect). (Baker, 1975, p.17) Skinner's ideas were quickly incorporated into classroom instruction by many other teachers. Thus the reintroduction of the concept of automatic self-instruction was extremely timely in light of the coming computer revolution. In the late 1950's, IBM researchers developed the computer language FORTRAN. This was a significant development as it made computer programming available to educators. Prior to this time all computer programming had to be done in complicated machine languages which consisted of 0's and 1's exclusively.

In the late 1950's an IBM 650 computer at the IBM Research Center was connected to a typewriter terminal and used as a dynamic Skinner teaching machine. Students typed in responses and interacted with the computer throughout the lesson. In 1960, Dr. Donald Bitzer of the University of Illinois invented and developed a teaching system called PLATO (Programmed Logic for Automatic Teaching Operation). PLATO's purpose was to add automation to the individualized instruction materials that existed at that time. A large computer and one typewriterterminal were the original hardware of the system. The decades of the sixties and early seventies saw PLATO expand from one teletype terminal to hundreds of remote plasma and CRT terminals. This same period saw the migration of PLATO and other CAI systems from the colleges to the high schools and elementary schools.

One of the forerunners of CAI for elementary aged children was Dr. Patrick Suppes of Stanford University. In 1964, Dr. Suppes initiated CAI with kindergarten, first grade, and fourth grade children in the Cupertino Union School District of California. (Baker, 1975, p.20) In the late sixties PLATO moved off campus and into the elementary schools of Springfield, Illinois.

One of the first school districts to own a computer was the Montgomery County Public School District of Maryland. By 1968 this school district had developed a timesharing large computer system using a number of visual display terminals connected to a large IBM computer.

By the end of 1974, the typical CAI program was university or large school district based, involved some students at nearly every grade level, and typically cost about $1.00 per student hour. (Doeri, 1979, p.119) All of this changed with the advent of the first microcomputer, the Altair 8800, in 1975. This microcomputer was soon joined by the Apple II and the Commodore Pet in late 1977. The microcomputer consists of four basic units, each of which performs a function of communication.

> "The keyboard allows the user to enter information in a form the computer can 'understand' (input). The TV monitor displays information in a form the user can understand (output). The cassette recorder (or, in more expensive machines the ultra-fast disk recorder) stores information, which can be 'read' at a later time (long term memory). The microprocessor is the brain of the computer and controls the operation of the other components, much as traffic lights control the flow of vehicles. It temporarily stores data while carrying out a 'recipe' or 'program' of mathematical operations and logical instructions." (Souvincy, 1980, p.54.)

For educators the greatest single advantage of the microcomputer is that of cost. The ideal educational tool which had been prohibitively expensive for all but the very largest of the nation's school districts had just become affordable.

> "A computer that cost $5 million in 1960 could be replaced for $500,000 by 1970. By 1975 $50,000 would buy a comparable machine. Today $3,000 will do the trick and in five years the price tag for an extremely versatile microcomputer will probably come in at under $500." (Souvincy, 1980, p.55)

The technology made an overwhelming advancement in the development of the microcomputer. This point is graphically told by Christopher Evans:

> "But suppose for a moment that the automobile industry had developed at the same rate as computers and over the same period: how much cheaper and more efficient would the current models be?... Today, you would be able to buy a Rolls Royce for $2.75, it would do three million miles to the gallon, and it would deliver

> enough power to drive the Queen Elizabeth II. And if you were interested in miniaturization, you could place half a dozen of them on a pinhead." (Braun, 1981, p.224)

The one dollar per student hour cost on the large computer has just been reduced to 11 cents with the introduction of the microcomputer.

While cost is the most significant advantage of the microcomputer, its other advantages also contribute to its desirability in educational settings. The microcomputer's size is only about 18 inches square and approximately 11 pounds. This certainly makes it compact enough to fit on a table top, unlike the space consuming teletype terminals of the large computer systems. Reliability is another dramatic advantage of the microcomputer. The use of LSI (large-scale integration) in the manufacture of the microcomputer's components has resulted in fewer internal computer breakdowns. (Braun, 1981, p.225) This coupled with no further dependence on phone lines has resulted in a great reduction in computer down time. Another noteworthy advantage is the graphic capability of the microcomputers. These machines have the ability to display complex visual images and animations that were impossible ten years ago. The sound and music generation of the machines is amazing. It is reported that some microcomputers can generate speech. This claim is exceeded only by the one which indicates that with a commercially available device an Apple II can recognize a limited set of spoken words. (Braun, 1981, p.225). The future for the microcomputer seems to hold two outstanding expectations. The microcomputer will become significantly more powerful and significantly less expensive than it is today.

The Implementation of CAI in the Elementary School

The implementation of CAI in the elementary school has a close and direct relationship with the advancement of computer technology. As one might expect, the application of CAI in elementary schools was severely limited until the development of the relatively inexpensive microcomputer. This is not to suggest that significant efforts in CAI were not being made until the late seventies. On the contrary there were major efforts toward developing CAI in the elementary schools; however, due to the high costs of the technology these efforts were limited to major universities and a few large school systems. The following discussion will focus on the development of a few of these projects.

The PLATO Elementary Math Experience

Perhaps the most notable and best documented of all CAI efforts is the University of Illinois' PLATO (Programmed Logic for Automatic Teaching Operation). While PLATO can trace its origins to the early sixties, it did not enter into large scale implementation on the elementary level until the 1974-75 school year. At this time PLATO Elementary Mathematics materials became part of the daily classroom routine for 1100 Champaign/Urbana fourth, fifth, and sixth graders. (Dugdale, 1980, p.7) These students represented a wide range in socioeconomic levels and scholastic abilities.

One of the major components of the PLATO Elementary Mathematics materials dealt with fractions. This program was carefully designed and revolved around several CAI instructional modes.

> "PLATO Fractions curriculum employs models used interactively, not just as illustrations and they provide mathematically relevant visual feedback in response to student manipulations. Lessons usually allow many different ways of solving the problems. This provides the opportunity for exploration, helps the student attend to the meaning of what he is doing, and helps avoid the notion that mathematics is simply the repetition of dictated algorithms.
>
> In addition to instruction, lessons are used for review, practice, or experience." (Dugdale 1980, p.1)

Elements of individualization existed in this program in the forms of individual assignments and pacing. Lessons were mastery based with the complexity of the task automatically varying according to the student's performance. Immediate feedback on a lesson was given directly following a student's response. The student's current performance level and the required mastery level were always displayed. The amount of time (pacing) required to complete a lesson varied widely among students. (Dugdale, 1980, p.1) Some of the lessons were designed for two student interaction at the same terminal. Other lessons allowed for student input which was saved and shared with other students. Teachers using the PLATO system reported that students rarely tried to "copy" another student because the lessons were so individualized. Frequent student interaction, other than that previously reported, did occur when a student accomplished something and wanted to show it or explain it to a friend. Sometimes a student would turn to a friend for help, but that help was usually restricted to just one problem. (Dugdale, 1980, p.2) Most students had an "I'd rather do it myself" attitude toward their lessons. The following description of a lesson from the PLATO Fractions Unit should serve to illustrate a typical PLATO elementary math lesson. The student sits down at a terminal equipped with a CRT and a typewrite keyboard. He/she begins the 30 minute program by entering the necessary identification information in the initial sign-on procedure. The terminal translates the student-entered information into an electronic message which is sent over telephone lines to the large computer at the University of Illinois. The computer finds the student's file in its recorded memory and then selects the appropriate review exercises for the students. Following a short review, the computer offers the student a list of several appropriate instructional lessons. These lessons are the main material that the student is studying. As the student masters the skills and concepts presented in these lessons, new lessons are automatically added to the choice list, while the lessons that have been mastered disappear from the list. (Dugdale, 1980, p.3) Students can enter and leave lessons at will, but must meet completion criteria in order to have access to new lessons by finishing old ones. Near the end of the session, the list of available lessons from which the student may select to work on is expanded to include several general experience lessons. Some of these lessons are games that reinforce recently or previously learned mathematical skills, while other lessons encourage initial exploration of new areas. (Dugdale, 1980, p.3) When the student's lesson time has expired the session is automatically over unless the student is not at a convenient stopping point. If it is inconvenient for the student to stop, then the computer allows him/her a few minutes to finish.

The Fraction unit and other elementary math units of the PLATO program were used as an adjunct to regular classroom instruction. These programs proved to be quite successful. An independent external evaluation of the elementary math PLATO programs by E.T.S. (Educational Testing Service) of Princeton, New Jersey, found these programs to yield significant positive achievement and attitudinal effects. (Dugdale, 1980, p.7)

> "Thus, there were significant positive PLATO effects at all grades on a nationally standardized (48-item) test of Computation and on a specially constructed (20-item) test of understanding and representation of fractions. The two higher grades showed significant positive PLATO effects on a test of graphs and linear equations, and grade 4 children exhibited a significant positive treatment effect on a test of understanding of whole number concepts and operations. Such grade-by-treatment interaction is consistent with the level of the strands: the whole number material representing review for many fifth and sixth graders, and the graphs material being quite advanced for many fourth graders." (Swinton, 1979, p.21)

Dr. Swinton of E.T.S also reported that the majority of elementary students found PLATO to be fun and to have helped improve their attitude toward math.

> "Items concerning PLATO itself revealed great majorities at each grade agreeing that 'PLATO is fun' and 'helps me like math better,' and majorities of fourth and fifth graders (but 49% of sixth graders) asserting that 'I learn math more easily on PLATO.' However, almost one-third of PLATO fourth and fifth graders and over half of sixth graders also agreed that 'PLATO is fun at first but after a while it gets boring.'" (Swinton, 1979, p.23)

It is interesting to note that although PLATO might become boring after a while, it still seemed to improve the student's attitude toward the subject. One final observation noted that while students enjoyed math better with PLATO than with their teacher, they recognized that they learned more math from their teacher than from PLATO.

> "Although fifth graders assented to 'I like math better with PLATO than with my teacher,' by more than two to one (the other two grades being about equally divided), children at all three grades disagreed with 'I learn more math from PLATO than from my teacher,' by well over two to one, suggesting that many children clearly differentiated enjoyment from learning, and saw PLATO as more strongly related to the former." (Swinton, 1979, p.24.)

The PLATO Elementary Reading Experience

PERC (PLATO Elementary Reading Curriculum Project) used the same large computer and terminal system as did the elementary mathematics program. However, the results for PERC were not nearly as satisfying. The program involved the same schools, but different grade levels as were used in the mathematics project. This program was aimed at beginning reading for children from the kindergarten to second grade levels. The lessons were intended to supplement, but not supplant, regular classroom instruction. The sophisticated terminals used advanced audio technology that unfortunately was given to rather frequent malfunction and breakdowns. (Swinton, 1979, p.8) Children also seemed to be rather overwhelmed by the use of highly sophisticated graphic displays on the terminals. (Yeager, 1977, p.5) Another technical problem experienced with the terminal was the use of a touch panel with a resolution of about one-half inch square; this was much too large for the small fingered first grade children. Children would try to respond but their fingers would slip in between the touch sensors and not be registered. This led to the superstitious habit of touching everything three to four times. Some children who knew the correct answers deduced PLATO was dumb when it failed to confirm the child's correct response or when the audio unit miscoordinated with the terminal and named the letter "A" as "B". (Yeager, 1977, pp.6,8)

Another failure in PERC was the programming. One of PERC's goals was to develop reading instruction which could be used independently at the terminal without the need for an instructor.

> "The fallacy of trying to provide independent instruction resulted in: (a) no area was covered effectively; and (b) many of the lessons which were produced never belonged on a computer; they would have been better done by a teacher or by some other medium." (Yeager, 1977, p.13)

In order to provide short and interesting lessons, about 2.5 minutes, which were appropriate for primary aged children, the programmers had to vary instructional format. The programming error was not in trying to develop 100 different instructional formats, but in developing nearly as many sets of directions for interacting with the computer. The resulting frequent changes in directions from one lesson to another confounded the young students. This fact is readily appreciated when one recognizes that a student may be exposed to as many as six different lessons and as many different directions in the space of the fifteen minute computer assisted lesson. Another criticism of the lessons leveled by both teachers and students was that they were too often filled with boring drill work.

The following summary statement by Dr. Swinton of the E.T.S. probably best states the overall performance of the PERC program.

> "The PLATO Elementary Reading Curriculum demonstrated negative impact on first-grade reading achievement in the pilot year and on kinderarten reading readiness achievement in the first semester of the demonstration year. No effect on attitudes toward reading was found. Additional ancillary hardware (in particular the audio device) with attendent production and implementation problems, and the immaturity of the target population (ages five to seven), were factors in this failure. However, in the opinion of the evaluators, the discrete and slow-moving curriculum, which in contrast to the mathematics lessons, did not focus strongly on meaning or understanding, was a major contributing factor to this disappointing outcome." (1979, p.28)

It is clearly evident that the overall performance of PERC was quite disappointing.

The overriding evaluation of the PLATO elementary programs focused on its cost and its potential.

> "Teachers and students were quite positive about PLATO and its potential. We concur, in that the medium is attractive, flexible, highly interactive, and offers immediate feedback to lesson authors. PLATO has demonstrated its potential as a curriculum test bed, for refinement and perfecting of lesson ideas first tried out in the classroom by talented curriculum developers. We would recommend support of such use, for eventual translation to more limited and economical delivery systems. However, without considerable cost reduction, particulary in communication costs, we do not see PLATO IV as an economically viable delivery system for elementary schools, even with

> lessons as attractive and effective as those developed by the PLATO elementary mathematics groups." (Swinton, 1979, p.29)

One can readily see that PLATO costs, particularly the communication-oriented ones, make it impractical for elementary schools. The PERC program did little to enhance PLATO to its evaluators; however, the math program clearly demonstrated its potential. In the final analysis, it is the cost of the large computer system, not its potential educational value which led to Dr. Swinton's rejection of PLATO.

Project OWN

The Montgomery County Public School System of Maryland developed a CAI program called OWN (Operations Whole Numbers). OWN was a program designed to strengthen students' computational skills in the four arithmetic operations. OWN was organized into four main sections, the four arithmetic operations. Each section had three main components; a pretest, a sequence of drills, and a review test. The pretest was used to accurately place the student in the appropriate drill. In each drill the student was given two attempts to enter the correct answer before it was scored as wrong. If his second answer was incorrect, he was given the correct answer. Time was allowed for the student to compare his incorrect answer with the correct answer, and to type and enter the correct answer prior to the presentation of the next problem. (Morgan et al., 1977,p.4) Upon completion of the drill sequence a review test was administered. To pass a review test the student must have 90% of the questions correctly answered. If a student fell into the 80% to 90% range, then the questions he incorrectly answered were identified and the computer would ask him to respond again. If the responses were correct and his accuracy was 90% or better, the student would be advanced to the next level as if he had scored 90% or better the first time. (Morgan et al, 1977, p.5) A student record was kept in each class providing the teacher with the student's current and past performance. This card was also a tool on which the student could enter a request for teacher help.

Project OWN was implemented into nine elementary schools from January, 1975, through June, 1976. Equipment for this project was a large centrally located computer, CRT student terminals, and the necessary modems for connecting the terminals to the computer via telephone lines. Each student was allotted 20 to 30 minutes terminal time each week.

Results of the project indicated that the third through sixth graders made significantly greater improvement in math learning than their non-CAI counterparts. Another observation of the Project indicated that the below average student appeared to benefit more in lower grades; whereas the above average student appeared to benefit more in higher grades. (Morgan et al, 1977, p.22) The following teacher opinions about Project OWN are noteworthy: one, 89% of the teachers thought it was a useful resource; two, 88% of the teachers thought it gave valuable diagnostic information about the students; three, 82% of the teachers felt that the program gave them a chance to individualize their mathematics program; four, 87% of the teachers had an overall favorable opinion of the program, and five, 90% of the teachers said the students enjoyed working at the terminals.

Bath Elementary School

Bath Elementary School of Richfield, Ohio, placed two computer terminals connected by phone line to the large computer at the University of Akron. The terminals were used by both reading and math teachers with satisfying results. The reading teachers reported an average growth of 2.4 more months in reading proficiency during the semester the students were on the computer than during the semester the students were not on the terminals. (Bowman and Dalton, 1979, p.2) In addition to this accomplishment the computer provided an unexpected benefit to slow readers.

> "...Because the computer prints as though there were a person typing the materials, the video terminal trained the eyes of several of the slowest readers to read faster. While it is not intended to be a speed reading machine, it did seem to cause most users to become faster, more careful readers." (Bowman and Dalton, 1979,p.2)

It should be noted that the students had only two months of daily computer instruction during the semester.

The high achieving sixth grade math students of the Bath Elementary School were taught a metrics unit by the same instructor who had taught the same material during the past three years. Two post tests were given: one, immediately following the unit; and a second, two months later. Results for first post test indicated that the computer assited class scored significantly higher (.05 level of significance) than the previous non-assisted classes. (Bowman and Dalton, 1979, p.4) The second post test demonstrated that the computer assisted class retained more knowledge than the unassisted classes. Another benefit of the CAI class was a one week reduction in time required to learn the metrics material over the previous unassisted classes.

Students in the basic math classes of Bath Elementary showed more understanding of mathematical processes and made fewer mistakes after working on the computer. The authors suggested that the computer's best assets were the immediate feedback which prevented the students' practicing a mistake and the computer's patience which allowed students as many practice repetitions as were necessary to learn a skill. (Bowman and Dalton, 1979, p.4)

Student attitudes were very positive toward working on the computer at Bath Elementary. It generated great interest and awareness in each student's individual learning progress. This was clearly evident by the large number of students that waited every Wednesday for the mailed computer printed statements about each student's progress.

> "Learning on the computer had a snowballing effect. The more they progressed through a program, the more they wanted to complete the program." (Bowman and Dalton, 1979, p.5)

Chicago

In 1970, the Chicago School System place a CAI system in its ghetto schools to teach reading and mathematics. By 1971, a large mainframe computer with 105 terminals in 32 schools was fully operational. Results of the program indicated that students from fourth through eighth grades, many of whom were 1.5 years or more below grade level at the beginning of the program, showed an average 1.1 years growth in reading levels over an eight month period. The Chicago School Board was impressed;they invested enough money to add an additional 40 terminals. (van Feldt, 1977, p.3)

The Microcomputer and Elementary CAI

Since the advent of the microcomputer, elementary school CAI has virtually left all other computer systems behind. The cost and reliability factors seem to be reasons enough for this move. The emphasis in the field is no longer directed at complicated hardware but rather toward software or program designing. In other words, curriculum development in the personage of computer programs is the major topic in elementary CAI. Few organizations have addressed microcomputer program development efforts as well as MECC (Minnesota Educational Computing Consortium). MECC is a programming service available to any school district at a relatively nominal fee. It provides the district with easily transferable programs in the BASIC language on floppy discs. Most of these programs are designed for the most mininal microcomputer system. Typically a system of 12K memory, on 8 bit microprocessor, a keyboard, and a printer or CRT is all that is required to run a MECC program. (Hinton, 1980, p.13) The ubiquitous Apple, TRS 80, or Commodore microcomputer can easily handle such minimal requirements.

A notable user of the microcomputer with elementary children is Dr. Seymour Papert of M.I.T. His approach is to teach mathematics intuitively using a microcomputer controlled "turtle". The turtle will follow any commands the student enters on the keyboard of the computer. Dr. Papert has not only achieved a level of intuitive understanding of mathematical relationships through use of the turtle, but he has also helped students learn some elementary programming.

The most typical microcomputer experience for the average elementary teacher is similar to that related by Geraldine Carlstrom of Lincoln Elementary School in Chisholm, New Mexico. She borrowed a friend's TRS 80, brought it to school, and used a program called Pit.

> "In the program titled Pit, for example, the objective was to get a man out of the pit before a rock rolled down the hill by answering basic math problems. Each correct answer allowed the man to climb further up the rope. The child's speed in solving the problem determined the distance the man climbed. When an answer was incorrect, the man did not move and the rock continued to fall. This technique was extremely motivating and helped the students learn speed and accuracy in solving math problems." (Souvincy, 1980, p.55)

This and other programs became an obvious hit with students and parents alike.

> "Not long after we started using the microcomputer I began to hear from parents, many of whom expressed surprise at the children's enthusiasm for math. One mother summed it up when she commented, "Chris said he wouldn't mind going to school all summer if he could use the computer." I was able to let parents know how their children were progressing by simply showing them the student progress sheets that accompanied the software packages.
>
> As for me, I found the microcomputer to be an innovative new tool for teaching. Besides its motivational benefits, it allowed me more freedom to individualize. I could spend more time with students who had specific learning difficulties while others used the computer for drill and retention." (Souvincy, 1980, p.55)

It could easily be suggested that Ms. Carlstrom's first experience with a microcomputer readily demonstrates many of its advantages. The ease of use of the programs, the great student interest, the computer's superiority in drill work, and the freeing of the teacher for other tasks are all apparent in this account. Although she had no statistical evidence of a successful experience with the microcomputer, she does indicate that students exhibited a high level of excitement and joy in learning during this period.

The Development of Elementary CAI Curriculum

"Garbage in, Garbage out!" This crude expression of computer programmers succinctly states the importance of well designed computer programs. It is axiomatic that the computer is only as good as the program which is inputted. The computer may be the Proteus of all machines, but it will never live up to its promise unless it is given appropriate programming. For educators the message is clear; learn how to recognize and to develop good educational programming, or don't bring the computer into the classroom.

The development of good educational computer curriculum (programs) is a long and somewhat arduous process. The ratio of development hours to student hours is 200:1. Thus it requires 200 hours of development to produce a program which the student uses for one hour. (Doeri, 1979, p.136) This ratio is far from incomprehensible after one examines the main steps that professional educational programmers take in developing their product. The following list will serve to illustrate this point.

(a) The objectives or aims of the program are specified precisely and in a way that can be measured. The objectives of a program state what it is that the student will be able to do when he has completed the program.
(b) The prior knowledge, skills and abilities of the students who are to use the program are similarly specified.
(c) The material to be taught and the skills to be acquired by the learner, are painstakingly analysed.
(d) From these analyses are determined (i) optimum teaching sequences, (ii) appropriate teaching strategies, and (iii) appropriate presentation methods (one of which may be programmed learning....).
(e) The program is tested on students for whom it is intended.
(f) On the basis of results obtained from empirical tryouts, the program is revised, retested, and revised again until it can be seen to be 'working' satisfactorily." (Hartley, 1972, p.14)

Some authors suggest that the setting of objectives is the most significant step in the development of a good program. (von Feldt, 1977, p.5) These authors suggest that understanding Bloom's general taxomony of learning skills and suggested questions for objective setting are very important in the design of good CAI curriculum. One other often overlooked step in program development is step (e), field testing the finished product. Past experience has shown that the best CAI materials have been through several rounds of field testing and consequent modification. (von Feldt, 1977, p.136)

The 200 to 1 ratio of development hours to student hours holds several ramifications for elementary teachers. The predominant implication is that the typical elementary teacher will more frequently choose a prewritten program for use in the classroom than write his or her own program. This situation is very similar to those occasions when the educator selects other items of curriculum. The choice of computer programs may be relatively trivial as in selecting a film, or relatively significant as in a school district's adoption of a reading or math text series. At the present time some textbook companies, programming and computer firms, and various educational agencies are providing programs for use in elementary schools. These programs typically bridge all forms of CAI. These considerations serve to enforce the thought that elementary educators need an outline for evaluating programs. The following list contains several helpful suggestions for accomplishing this end. This list is to be considered as a starting point, not as the be all and end all of such evaluation tools.

> "1. Is there documentation - printed support material - to accompany the cassettes or disks? Many programs do not provide documentation, and there is no way for a teacher to get answers to some questions from the program itself, which is preset.
>
> 2. Does the program run? This question may sound foolish, but in fact there are technical problems with many of the programs that arrive over our desks....
>
> 3. Is the program easy to use? The instructions for proceeding from step to step must be part of the program, so that a student knows what to do at any point. The format should be consistent so that the student gets used to whatever the style of the particular program is and does not have to learn new commands or stop to figure things out.
>
> 4. Is the activity educationally sound? A computer program is a piece of instructional material and the teacher is the best judge of the utility of any instructional material.
>
> a. Is the activity appropriate to be integrated into the concepts to be taught?
>
> b. Is the activity appropriate for the age of the students? Is the language? Are the spelling and grammar correct?
>
> c. Are the responses called for reasonable for the students?

d. Is the computer essential to the activity or is it simply being used to juice things up? Would the activity be better in another medium such as print?

e. Is the program attractive and interesting?

5. Who is in control - student or machine? Ideally, the student should be able to determine the length of time an iten stays on the screen and should have as much time as needed to read and understand the information before pressing the return key. Allowing the user to be in charge tailors the program to individual needs and helps take away the intimidation that machines have for some students.

6. Does the program present the concept to be learned in a harmonious and well-balanced way? Does it use text and graphics in mutually supportive ways to make the learning more clear? If it has sound, does the sound work well with the other components? Is the text easy to read - are the lines of a reasonable length, does rollover of lines cause confusion, is the color useful or just gimicky? In summary does every piece of the program serve to make it a better teaching item or could it be streamlined to a better effect." (Naiman, 1982, pp.34-5)

Although much of the programming the elementary teacher may need will most likely be prepared by some other source; there will be occasion for the teacher to do some of his or her own programming. Instances of these situations would include preparing a review for an upcoming test, a brief tutorial program for a number of absent students, a quick drill for a student needing work on addition facts, or isolated spelling words, or a host of other minor situations requiring relatively immediate attention. (Doeri, 1979, p.134) Teachers have been handling these everyday challenges for years; the computer should free them from these tasks so that they may attend to other responsibilities.

The program required for the addition facts drill can be written in as few as seven lines of code. The program code and the student display are listed below:

```
Student Display          Program Code

5 + 3 = 6                10 X=INT (RND (TI)*10)
WRONG, TRY AGAIN.        20 Y=INT (RND (TI)*10)
5 + 3 = 8                30 PRINT X"+"Y"="
6 + 2 = 7                40 INPUT Z
WRONG, TRY AGAIN.        50 IF Z=X+Y THEN 10
6 + 2 = 8                60 PRINT "WRONG, TRY AGAIN."
1 + 4 = 5                70 GO TO 30
and so on.                         (Doeri, 1979, p.123)
```

This program highlights the idea that the computer literate teacher could very easily write a program to satisfy a student need. The more literate teacher could write a program of only 22 lines of code which would count the number of problems the student tries, give the correct answer after the student makes three wrong attempts, print the student's name, use positive statements for correct answers, and give a final accounting of the student's performance.

A predominant theme in the designing of CAI curriculum is that too much of our present curriculum puts the machine in the stimulus role and the student in the response role of the stimulus/response paradigm. The more desired goal is for the student to give the stimulus and the computer to give the response. (Yeager, 1977, p.17) The following six conventions strive to rectify this situation.

"(1) <u>Maintain a high interaction rate.</u> The student must be able to interrupt the computer in order to make a correct response.
(2) <u>Make the response as meaningful as possible.</u>
(3) <u>Keep remediation to a minimum.</u> All remedial sequences must be interruptable to allow students to enter the correct answer.
(4) <u>Procedural errors are ignored or remediated on a schedule.</u> Procedural errors are those responses which have nothing to do with the possible answer.
(5) <u>Always force the student to make the correct response.</u>

(6) Overt reinforcers are faded away quickly. Reduce elaborate displays and animations as soon as possible; particularly when working with very young children." (Yeager, 1977, p.18)

Past experience has demonstrated that teachers can write good large scale CAI programs. Many of the programs developed in the Montgomery County CAI project were teacher authored as were the programs developed for the INDICOM project (Waterford Township, Michigan). (Grobe, 1974, p.40)(Arnold and Penny, 1969, p.88) Both of these projects gave a cadre of teachers significant amounts of in-service training in lesson design and programming. Professional computer programmers assisted teachers in their efforts to write programs. Results of these projects suggest that teachers when working in concert with programming experts can generate some very fine, sophisticated curriculum.

The Advantages and Disadvantages of Elementary School CAI

The advantages of elementary school CAI are numerous. The mere description of a computer's capacities is an educator's dream.

> "A machine which can present complex symbolic and graphical displays, can put these displays under student control, and can adjust the nature and sequence of such presentations according to complex decision rules ought to be a very effective instructional medium." (Jacobson, 1973, p.4)

The computer is a "very effective instructional medium." The most significant advantage of the computer is its ability to provide individual instruction. The computer can be programmed to recognize an individual's needs and then provide need appropriate curriculum.

(Jacobson, 1973, p.5-6) Individualized learning is a definite educational advantage.

> "The literature of individualized learning/ instruction systems indicates that these systems work as well or better than traditional, conventional instruction. Students learned more, made higher grades, saved time, performed better on examinations, and felt improvement in self-confidence." (Hinton, 1980, p.1)

Clearly the ability to move through a course of study as quickly or as slowly as one wants is a benefit to productive learning. The ultimate advantage in computerized individualization of instruction is that this benefit is delivered more inexpensively by the computer than any other medium. (Jacobson, 1973, p.7)

A second benefit in elementary CAI is that it can significantly upgrade student performance. (Doeri, 1979, p.121) Students at the elementary level who were two years or more below grade level in mathematics have gained up to 1.35 years after one year in a program consisting of ten minutes per day of computer instruction. (Doeri, 1979, p.122)

A third benefit is that CAI can be highly motivating to underachieving students. (Doeri, 1979, p.121) The computer's novelty is seen as catching the student's interest and holding it with an unhurried pace and noncritical comments. A corollary of this benefit is that the same computer can also help the learning disabled and the gifted student. (Florida State, 1980, p.8) For the disabled student the computer can offer a powerful tool for exploring content areas or testing theories in computer simulations. The computer provides the learning disabled with the patient drill and practice, reinforcement, and stimulation which helps these students to learn. (Florida State, 1980, p.8)

A fourth benefit of elementary CAI is that it can ensure that students are delivered the best application of proven teaching methods to all students at all times. (Doeri, 1979, p.121) The computer does not have a dominating personality, nor is it ever impatient. The computer will maintain a level of student interaction and will never permit the student to practice an error. In addtion, the psychological benefit of immediate, positive reinforcement will further the student's learning. (Texas, 1977, p.3)

A fifth advantage of CAI is that it can help a teacher to better diagnose areas of student weakness. (Doeri, 1979, p.121) A well written CAI tutorial or drill and practice lesson will often carry through record keeping provisions. These provisions can identify frequently missed skills which the teacher can then remediate.

A sixth advantage of CAI is that it can cause a shift in the role of the teacher from adversary to ally. (Doeri, 1979, p.121) The rationale for this statement is that in the conventional classroom the teacher is the one making assignments and judgements. In the CAI classroom the teacher functions more as a coach helping students master material.

A seventh benefit of CAI is that it allows an increased student/teacher ratio without the students' performance being adversely effected. (Doeri, 1979, p.121) This advantage applies to those occasions when students are doing drill and practice or make-up lessons. When this occurs the teacher is free to interact with greater numbers of students. (Doeri, 1979, p.121)(Souvincy, 1980, p.57) Some authors suggest that the teacher may be freed up to 30% of the time. (Jacobson, 1973, p.17)

Whereas, the advantages of elementary CAI were numerous, the disadvantages of elementary CAI are few. Most of these disadvantages refer to equipment failures with the terminals employed by the large computer systems. Another complaint of the terminal is that it is limited to only one student at a time because of its individualized approach to instruction. (Perry, Keyser, 1979, p.174) Another equipment complaint is that teletype terminals are noisy and distracting. (Texas, 1977, p.3) The advent of the microcomputer and CRT display eliminates this and other terminal complaints.

Most of the remaining detractions toward elementary CAI revolve around cost and lack of courseware. The cost complaint is directed toward the expense of the computers, themselves, and courseware development costs. (Rushby, 1981, p.137) The sting of high costs for computers is quickly dissipating each year the microcomputers are marketed. The courseware costs will remain high as long as it takes 200 hours to develop one hour of student programming. However, this problem could be deflated if economies of scale begin to operate in this field.

The Future of CAI in the Elementary School

On a broad scope the distinction that now exists between CAI and other forms of elementary curriculum will most likely disappear in the future. CAI will no longer be thought of as a separate field but rather as a component of a larger curriculum. That curriculum will be better organized and more interrelated. Computer lessons will no longer be isolated ventures into a new technology. In essence, the use of the computer in the elementary classroom will be focused on helping students learn, not on getting them to use a computer. (Jacobson, 1973, p.13)

In the future computers will be individualized not only in the realm of instructing but in the field of learning styles. The computer will be programmed to deliver the same information in various ways in order to accommodate the individual student's learning style. Our understanding of learning styles should be enhanced by the computer's ability to record, sort, and categorize all of the student's responses. Ultimately the educator will not start out with a computer but rather with an educational problem. The problem will be evaluated and the computer will be used to solve that problem in concert with other educational tools. (Jacobson, 1973, p.21)

The following projections for the use of computers in elementary schools in 1990 should prove interesting. While little empirical evidence suggests how much time a student should spend in daily computer instruction the author suggests that a 30 minute daily session should be reasonable.(Melmed, 1982, p.309) Thirty minutes would amount to 10% of a five hour school day. (Melmed, 1982, p.309) To accommodate a 30 minute per day session with an interactive computer, the nation will need a total of about four million computers for both elementary and secondary schools. (Melmed, 1982, p.310) If we are to accumulate this number of computers in our schools, we will need to increase our total nation-wide computer inventory by 50% per year from 1980 to 1990. (Melmed, 1982, p.310) Once this figure is achieved it will take about one billion dollars annually to upgrade and replace worn out machines. This cost is calculated by multiplying the 1,000,000 newly purchased computers times a projected $1,000 (in 1982 dollars) per copy price. (Melmed, 1982, p.310) All of this boils down to hardware cost of approximately $25 per pupil per year. The other major expense in CAI is software (courseware). Melmed suggests that courseware costs would be about 96 million per year for the nation's school children, or about $2.40 per pupil. (Melmed, 1982, p.310) Essentially for less than $30 per student per year, each elementary and secondary student could have 30 minutes of daily CAI, a figure that would represent about 1.2% of the projected 1990 annual instructional budget. (Melmed, 1982, p.310) The author suggests that the following conditions could delay the full use of computers in the classroom for as much as 20 years.

> "The portion of the school budgets available for the purchase of instructional materials is probably too small to purchase enough computer units.
>
> The current inventory of education courseware available for student use is inadequate.
>
> Current investment in developing new approaches to the student use of computers is inadequate. (Melmed, 1982, p.310)

The ultimate fear is that educators will allow these factors to interact, consequently, reinforce each other and prevent the realization of the 1990 goal. The author suggests that the federal government and private foundations should provide capital to help develop courseware and spur the introduction of more computers into the classrooms.

Seymour Papert of M.I.T. proposes that every student be given a microcomputer upon admission to school. (Braun, 1981, p.226) He argues that children should have access to a computer anytime they wish, not just the 20 minutes per day that is typically available to students attending schools with computers. He supports the argument with the idea that a computer costing less than $1000 would represent an expenditure of only three percent of the cost of educating the child through the twelfth grade. (Braun, 1981, p.226)

Dr. Papert's idea has some prima facia merit; however, there may be some flaws which could negatively impact on his cost calculations. First, he does not consider any replacement costs or repair costs. A computer life span of approximately five years was used in Melmed's calculations. Second, there are no courseware costs calculated in this estimate. Third, computer technologists suggest that there are many technological improvements yet to come in the microcomputer field. This would suggest that by the end of a child's elementary school career he may have an outmoded machine incapable of handling advanced courseware. Nevertheless, the idea of a computer for every child is appealing. Whatever course we do take, indications are that extensive use of the computer in schools will begin between 1990 and 2000. (Long, 1982, p.312)

Chapter 3

SUMMARY AND CONCLUSIONS

Summary

The overwhelming characteristics of CAI is individualization of instruction. The computer is the only educational medium today which can provide individualized instruction in a logistically acceptable manner. The computer is an effective educational agent in that it requires frequent student interaction and provides immediate reinforcement. Another noteworthy characteristic of CAI is its four distinct types of instructional programming. This fact gives credence to those who suggest that CAI can be more than just drill and practice activities.

Today's computers are nothing short of a technological miracle. They process information and perform complicated functions at the speed of light. The computer spends more of its time waiting than it does working. There is a close relationship between the technological advancements in the computer and the feasibility of CAI. The financial costs of the computers of the fifties, sixties, and early seventies made CAI impractical for the great majority of schools. Coincident with the technological development of the computer were renewed interests in programmed learning and an awareness for the need to individualize instruction.

The first effects in implementing CAI with elementary aged children produced bittersweet results. Many studies suggested that computer assisted instruction had great educational promise, but were flawed with high costs, unreliable terminals, and questionable courseware. Some large districts, Chicago and Montgomery County, brought CAI to their elementary children and enjoyed educational success. However, the number of school districts with a CAI program remained very limited until the advent of the microcomputer. The microcomputer was the second revolution in the computer field which brought computers within the grasp of nearly every school.

CAI curriculum (courseware) became the focus of everyone's attention as computers became available. Educators soon realized that the computer was no better than its courseware and that the development of good courseware was expensive and time consuming. Cadres of teachers were organized to develop courseware in conjunction with professional programmers. Organizations such as MECC came on the scene to function as clearing houses disseminating microcomputer courseware. Educators became more aware of the steps involved in courseware writing. Some educators learned to write simple programs for their own use. Methods for evaluating courseware are becoming more important as commercial courseware becomes available.

The advantages of CAI far outweigh the disadvantages. In fact, many of the disadvantages are being eliminated as computer technology advances. There is a veritable laundry list of advantages for elementary CAI. The computer's credits include motivating the student; providing beneficial individualized instruction; delivering consistent, positive, and even-tempered instruction, freeing the teacher to spend more time with smaller numbers of students;

individual needs of each student; and improving student performance in learning.

The future of CAI envisions the nation's school districts possessing four to five million microcomputers by the 1990's. By this time the typical elementary student would be spending at least 30 minutes a day in CAI. To accomplish this goal school districts would need to spend a little more than 1% of their annual instructional budgets. Several factors such as lack of courseware, cost, and lack of investment in developing new educational uses of the computer may inpede the implementation of CAI in the elementary schools.

Conclusions

The development of appropriate courseware will probably be the most significant single factor in the success or failure of elementary CAI. It is imperative that educators take an aggressive role in assuring that computer courseware follow principles of good lesson design. Teachers will need to work in close association with computer programmers in designing courseware. Educational courseware design may become a special branch of education in and of itself. Teachers will need to become computer literate. There will be occasions when the teacher will need to do some instructional programming of his/her own in order to meet a student's needs. It will be the responsibility of teacher education institutions and school districts to educate present and future teachers in the fundamentals of computer programming. State and federal education agencies will need to assist school districts in the development of courseware. Institutions such as

MECC will fulfill a role which will grow in importance as more and more schools adopt CAI.

Educational psychologists will need to further identify learning styles in order that the computer can more completely individualize instruction. As the level of courseware sophistication advances, students will be identified by their unique learning styles. The student will then be matched to the courseware that teaches in a mode best suited for his learning style. This will give new meaning to the concept of individualized instruction.

If we are to deliver an average of 30 minutes of daily CAI to our elementary students, then we will need to purchase more microcomputers. In order to accomplish this instructional goal and to provide a small cushion for computer breakdown, we will need to equip each elementary school with one computer for every eight students. It must be recognized that this is a minimum goal which is not beyond most school budgets. However, if we are to meet the 30 minutes of daily instruction goal we must begin making these purchases immediately.

Educators will need to recognize that they have just scratched the surface of the ways to use a computer. Research will need to be conducted to further expand the many educational horizons offered by the computer. Dialogue between teachers and theorists will be important in this effort. If this area is successful it will impact on courseware and the need for computers in our schools.

Education has many serious challenges which it will need to address in the next ten years. If we are successful in answering those challenges, it is quite probable that the computer and CAI will be a large part of the answer.

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