1981

CAI: The way to computer literacy through story problem solving on the microcomputer

Michael Clyde Merchant
University of Northern Iowa

CAI: The way to computer literacy through story problem solving on the microcomputer

Abstract

This paper is a review of available studies and literature publi5hed over the past ten years. Its purpose is to suggest the need to use the microcomputer CAI in story problem solving in the elementary school. The literature was reviewed on 1: the cost effectiveness of ii CAI and microcomputers, 2: the need for an instructional format which makes individualization a feasible teaching technique for most teachers in solving story problems, 3: the need for computer literacy as a goal of our educational system, and 4: the effectiveness of CAI in elementary reading, mathematics drill-and-practice, and story problem solving. A study of the literature reveals that CAI is an effective teaching tool. There is need for more individualization when teaching story problem solving because of the individual differences not only in rates of learning, but in approaches to problem solving. Computer literacy is becoming more and more important as society becomes more and more dependent on the computer in everyday life. The review finally states that, because of the relative success of CAI, its ability to adjust to individual needs, the similarity between the computer and the microcomputer, and the cost-efficiency of CAI and the microcomputer, the combination of the microcomputer and CAI is a feasible answer to these challenges.

CAI: THE WAY TO COMPUTER LITERACY THROUGH STORY PROBLEM SOLVING ON THE MICROCOMPUTER

A Research Paper

Submitted to

The Department of Curriculum and Instruction

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts in Education

UNIVERSITY OF NORTHERN IOWA

by

Michael Clyde Merchant

Summer, 1981

This Research Paper by: Michael Clyde Merchant

Entitled: CAI: The Way to Computer Literacy Through Story Problem Solving on the Microcomputer

has been approved as meeting the research paper requirement for the Degree of Master of Arts in Education.

Roger A. Kueter

July 24, 1981
Date Approved

Director of Research Paper

Robert R. Hardman

July 24, 1981
Date Approved

Graduate Faculty Adviser

Robert R. Hardman

July 24, 1981
Date Approved

Graduate Faculty Reader

Ernest K. Dishner

7/24/81
Date Approved

Head, Department of Curriculum and Instruction

Abstract

CAI: The Way to Computer Literacy Through Story Problem Solving.
Michael C. Merchant, 1981.

This paper is a review of available studies and literature published over the past ten years. Its purpose is to suggest the need to use the microcomputer CAI in story problem solving in the elementary school.

The literature was reviewed on 1: the cost effectiveness of CAI and microcomputers, 2: the need for an instructional format which makes individualization a feasible teaching technique for most teachers in solving story problems, 3: the need for computer literacy as a goal of our educational system, and 4: the effectiveness of CAI in elementary reading, mathematics drill-and-practice, and story problem solving.

A study of the literature reveals that CAI is an effective teaching tool. There is need for more individualization when teaching story problem solving because of the individual differences not only in rates of learning, but in approaches to problem solving. Computer literacy is becoming more and more important as society becomes more and more dependent on the computer in everday life. The review finally states that, because of the relative success of CAI, its ability to adjust to individual needs, the similarity between the computer and the microcomputer, and the cost-efficiency of CAI and the microcomputer, the combination of the microcomputer and CAI is a feasible answer to these challenges.

Table of Contents

Page

List of Tables v

List of Figures vi

Chapter

1. Introduction 1

Introduction to the Problem 1

Statement of the Problem 3

Definition of Terms 4

2. Review of Literature 5

Introduction to the Literature Review 5

Literature Review 6

Summary 28

3. Summary 30

Introduction to the Summary 30

Summary 30

Discussions and Conclusions 33

Limitations of the Study 34

Implications for Further Research 34

Implications for Future Use 35

Bibliography 36

List of Tables

Page

Table I 8

Table II 12

Table-III 13

Table IV 19

List of Figures

Page

Figure 1 Flow Chart for Solving a Word Problem in Mathematics 16

CHAPTER I: INTRODUCTION

Introduction to the Problem

In the decade of the 1970's, several factors developed independently of each other which have had and will continue to have a negative effect on the student, teacher, and classroom of the future. The first factor and probably the most important one was the discovery, through the use of standardized achievement tests and observation by the classroom teacher and other school personnel, that students were becoming increasingly less effective in both computational and problem solving skills in arithmetic. This decline was attributed to several factors. The decline of computational skills was blamed on the so-called "modern math" because of the lack of drill and practice on basic facts provided in the textbooks. Textbook manufacturers need not take full blame for this oversight. Teacher training institutions also emphasized the teaching of theory and de-emphasized (indeed, hardly mentioned) drilling on basic facts. This statement is supported by the personal experience of this writer and the statements of several of his colleagues. All of whom attended such classes throughout the late 60's and early 70's.

The solving of story problems requires that students first have the computational skills necessary to find the required solution. It also requires that the student be able to read and understand the problem. Again, in the 60's and 70's we see a decline in the ability of students to read material appropriate to their grade level. Once again we must look at the textbook publishers and place some responsibility on their shoulders. A study of story problems over a 100 year period conducted by this writer shows that story problems had not only decreased in complexity, but in the total numbers available for practice in the textbook. (Merchant, 23, pp. 1-17).

The difficulty experienced by students in working with story problems and the difficulty encountered by teachers in attempting to instruct students in the methodology of solution of story problems has come to the attention of such groups as the Iowa Council of Teachers of Mathematics. One need look no farther than the schedule of the 1980 ICTM Conference held in Des Moines, Iowa to realize the importance attached to the teaching of solving story problems. Almost all of the sessions and work-sessions held dealt with the teaching of problem solving and story problem solving, and with the use of micro-computers in the classroom. The 1981 conference continued its emphasis on the microcomputer and problem solving and added several sessions on meeting the individual needs of the students in the class-room. Both conferences were attended by this writer and the importance attached to problem solving, teaching story problem solving, and the use of the microcomputer in the classroom were unmistakable.

The phenomenon of television cannot be ignored. Children in today's schools have grown up under the influence of television. They have fingertip entertainment simply by turning or pushing a switch. Television's influence cannot be ignored. It has made the teacher's task even more challenging. How does the classroom teacher compete with the slick professionalism of a trained entertainer? What can make a story problem as interesting as a detective story? (Elsing, 11, pp. 12-13).

Paradoxically, the same technology that has provided such challenging competition for the classroom teacher has also provided a medium which can greatly enhance and improve the teaching of story problem solving. This technological assistant is the microcomputer. Because of continuing technological advances, the costs of using micro-computer in the classroom is continually decreasing, making it economically possible to place one of these electronic assistants in the classroom setting.

It is the intent of this paper to develop a case for the use of the microcomputer as an integral part in the support of regular class-room instruction in teaching story problem solving techniques. To accomplish this, it is the intent of this study to use existing research covering the successful use of computers in reading instruction, mathematics computation, problem solving, and the difficulties faced by children in understanding and solving story problems.

Statement of the Problem

Teaching the solving of story problems has historically been a difficult task. A task made even more difficult by the developments discussed in the introduction. Teaching how to solve story problems requires that students work alone or in pairs in order to be most successful. In a classroom where the reading levels of students in the same level in math may vary from a second grade level to a seventh or eighth grade level in reading, it is humanly impossible for the teacher to provide a program that successfully adjusts to such a wide range of differences and to adequately assist each student and to maintain accurate records of progress for each student.

Much has also been written of the need for tomorrow's citizens to have literacy and knowledge of computers. The development and use of a tutorial program for the microcomputer which not only assists the classroom teacher in individualizing instruction in story problem solving, but assists and allows students to do simple programming by helping them write their own story problems would not only result in students who are successful problem solvers but in citizens who are literate in the computer.

This study will review literature which reviews the success of CAI in reading, math drill, and problem solving. Literature concerning the need for computer literacy, and better methods of teaching the solving of story problems will also be reviewed.

Definition of Terms

CAI - Computer Aided on Computer Assisted Instruction.

CMI - Computer Managed Instruction.

Microcomputer - Refers to personal computers about the size of an office typewriter, which contains its programs on a floppy disk or cassette tape.

CHAPTER II: REVIEW OF LITERATURE

Introduction to the Literature Review

During the past decade it has become increasingly apparent to the classroom teacher that changes in the approach to the teaching of solving story problems are necessary. Research shows that students generally experience little difficulty in the mechanics of mathematics. Textbooks in mathematics published in the last five years have concentrated their material toward rote learning and the lowest level skills at the expense of teaching students to think through problems. "Students have difficulty deciding which computational skills to use to solve word problems and lack understanding of such concepts as fractions, decimals, and percents." (Education, 10, p. 1)

It is the intent of this paper to show, through the use of research already conducted on the successful use and application of the computer and CAI in the areas of reading instruction, basic arithmetic facts drill and practice, and problem solving, the likelihood that the microcomputer can be used on a cost-effective basis to increase student competency in solving story problems.

This review will first consider the success of CAI in reading instruction, CAI's effectiveness in arithmetic basic facts drill and practice and problem solving instruction will also be investigated as will research showing the need for a new or revised approach in teaching story problem solving. Because of the relatively recent appearance of the microcomputer on the educational scene and its comparable capabilities to the large computer systems in the area of educational programs this paper will consider research already compiled on CAI programs used in the large computer.

Literature Review

Research is available which shows a direct correlation between skill in reading and success in reading in the content areas. In a research paper by Garton in 1973, the results of several studies have been compiled which show that (1) student achievement in solving story problems is improved when the student understands the vocabulary used, (2) the student is able to interpret the words and expressions used, and (3) the student is familiar with a procedure or procedures by which a solution to the problem may be found. Studies also show that a student's ability to compute complex numerical problems does not insure that student's success in a story problem utilizing the same operations but written at a reading level beyond the same student's ability to comprehend. The research summation states that the teacher's responsibility for teaching story problem solving lies in teaching not only the mathematical and numerical concepts, but in teaching vocabulary, problem-solving reading skills, and the ability to use mental imagery to clarify word meanings. (Weber-Garton, 37, pp. 23-28). It is for these reasons that this paper will review research done on CAI in both the areas of beginning and remedial reading instruction, and mathematical computational skills, and problem solving.

Research findings on the use of CAI in reading strike a positive note. In a study conducted on two beginning reading curricula using CAI that were developed over a twelve year period at Stanford University, the following conclusions have relevance here. The CAI was developed with intent for use as a supplement to classroom instruction. (Fletcher, 12, p. 34) Teachers involved in the study made the observation that the students enjoyed working on the content to a greater degree than with a regular program. (Fletcher, 12, p. 35) Notably, Fletcher and Atkinson (1972) found that their sample of beginning reading students in these programs scored significantly higher on the paragraph meaning subtest of the Stanford Achievement Test than did a control sample of non-CAI students. (Fletcher, 12, p. 37) Fletcher concludes his study with this statement.

> "If the central problem in beginning reading is to make it sensitive on a moment-to-moment basis, to the individual needs of students, then CAI may be the most cost-effective alternative for large scale solution of this problem." (Fletcher, 12, p. 39)

In a report concerning the PLATO IV Computer-Based Education System with curricula ranging from elementary reading and mathematics to college and university offerings in accounting, biology, chemistry, English, mathematics, and physics the one evaluation common at all levels was that teachers and students alike enjoy and benefit from the program. (Slattow, 29, p. 97)

The PLATO Elementary Mathematics Project was tested for a three year period, 1974-1977, in the public schools at Champaign and Urbana, Illinois. For the 1975-1976 school year using Level 2 (Form R) of the Comprehensive Test of Basic Skills, a difference in mean gain of .3 or three months for the PLATO group over the non-PLATO group was shown for the year. Overall gain for the PLATO group was 1.4 years growth.

Table I: Comparison of 1975-1976 Test Results for PLATO Elementary Mathematics Project

		Fall		Spring		Gain
	N	Mean	S.D.	Mean	S.D.	
PLATO	129	5.0	1.58	6.4	1.70	1.4
Non-PLATO	129	5.0	1.62	6.1	1.66	1.1

(Dugdale, 8, p. 25)

"There is less than one chance in a hundred that a difference this large could have occurred by accident (matched p t (128) = 2.807, p = .0058)."

(Dugdale, 8, p. 25)

In addition to the academic achievement, the enthusiasm generated by the PLATO program carried over into other mathematics endeavors. The pupils in the PLATO group exhibited an improved scholastic and social attitude and sought extra practice sessions in comparison to the non-PLATO group. (Dugdale, 8, p. 46)

In a case study on the effects of the computer-based PLATO (Programmed Logic for Automated Teaching Operations) mathematics curriculum on the classroom environment and the children in it, data obtained over a two year period showed both teacher and children benefited in achievement, typing, reading and enthusiasm in mathematics. The data was obtained through observations and interviews of one teacher and selected students taking a cultural perspective and using anthropological techniques in the investigation. (Stake, 34, p. 22)

An investigation into the effects of varying amounts of CAI in mathematics on the academic performance of 446 fifth and sixth graders scoring below the norm on the California Test of Basic Skills (CTBS) yielded some positive factors on the side of CAI. The independent variables in this investigation were (1) beginning-of-year (CTBS) mathematics pretest scores; (2) teacher's verbal ability; (3) years of teacher experience; (4) teacher degree level; (5) student self-expectation; (6) number of CAI sessions had by a student during year; and (7) intelligence test score. End of the year CTBS test scores were compared with these independent variables using linear, Cobb-Douglas (homogeneous and nonhomogeneous), and transcendental logarithmic model specifications of student achievement. One benefit as a result of the 100 5-10 minute CAI daily and weekly sessions was that the student achievement in most cases was raised by as much as .3 years over what would otherwise have been the case. Another benefit resulting from the use of CAI as a compensatory education alternative was the lower cost. The cost at the time of testing ranged from $25 to $75 per student per 100 sessions per year, substantially less than most other alternatives for compensatory education. (Wells, 38, pp. 41-45).

A CAI course consisting of one hundred twenty packages ranging from addition of non-negative integers and other elementary topics to coordinate geometry, the binomial expansion, and other upper level subjects was tested. Each package consisted of three programs; problem set, answer-checking set, and a test composition set. In one case, a tenth grade mathematics class which had shown total disinterest and was not turning in any work began, after being introduced to the terminal, to work on assignments voluntarily over 45 minute unsupervised periods and was able, as a group, to raise their scores, catch up their work, and pass the course. The significance of this study is the motivating factor intrinsic in CAI for even the most reluctant learner. (Blakeway, 4, pp. 16-21)

In an evaluation of the OWN program, a drill program in the four basic arithmetic operations, conducted from January, 1975, to June, 1976, significantly greater improvements were made by students using this program over students using the traditional approach. The evaluation involved third through sixth grade students in nine schools in Montgomery County, Maryland. Third and fourth graders using the OWN program who had scored below average on the pretest averaged from 3.6 to 4.2 months gain over students using the traditional approach while students scoring in the average range on the pretest showed 1.1 to 3.6 greater gain over a fourteen month period. Of equal interest are the results of a Likert-type questionnaire given the teachers which showed an 87% overall favorable opinion of the OWN program and a 90% favorable response on the question of student enjoyment of the program. It was also noted that students showed no loss of interest over the period of time they used the program. (Morgan, 26, pp. 22-24)

Jacobson, Murray, and Thompson conducted a 1975 study of self-managed learned using CAI based on Unit E Multiplication of the IPI Mathematics curriculum. The results showed a gain of 1.4 years for the self-managed group as compared to a gain of 1.5 years for the comparison group using standard instruction. The beginning levels of each group were 4.2 years and 4.3 years respectively. Implications of this study are that the students in fourth and fifth grade were able to effectively manage their learning in elementary mathematics and apparently learned faster and retained material better than a comparative group of students using a traditional approach. (Jacobson, 18, pp. 10-11)

A study published in 1975 evaluated CAI in the Title I program in the Fort Worth Independent District in Fort Worth, Texas. The program was evaluated as being successful with some special notes of interest being made. The lower scoring students on the ITBS made greater gains than did higher scoring students, and third and fourth grade students made significantly more gain than did the other grade levels tested. The data collected was based on the concepts and problem-solving subtests of the ITBS (Iowa Tests of Basic Skills) and the Mathematics Applications section of the Stanford Achievement Test. (Lysiak, 21, p. 46) The comparison groups were taught by Title I resource teachers using the traditional materials and methods of the Title I program. The study stated that CAI was successful in terms of achievement and its used resulted in positive student and teacher attitude. Beneficial side effects on spelling, motivation, attendance, and independent work habits were also noted. (Lysiak, 21, p. 44) (See Table II)

In another portion of the same report concerning the Title I Secondary Reading versus CAI results indicate that the students receiving special reading instruction in the CAI program made significantly greater gains on the Gates than did the students in the Title I Secondary Reading Program. CAI students at all ability levels made

Table II: Summary of Significant Differences in Reading and Mathematics for CAI and Resource Teacher Students

	Mathematics			Reading			
		Stanford		Gates-McGinitie		ITBS	
Grade Level	ITBS	Application	Computation	Read Comp.	Vocab.	Voc.	Reading
3	sig CAI	N.S.	N.S.			sig CAI	sig CAI
4	sig CAI	sig RT	N.S.			sig RT	sig RT
5	N.S.	N.S.	N.S.			sig RT	N.S.
6	sig CAI		sig CAI	N.S.	sig CAI	sig CAI	N.S.
7			N.S.	N.S.	sig CAI		

(Lysiak, 21, p. 46)

larger gains than their peers in Title I Reading Program. (Lysiak, 21, p. 70 (See Table III)

Table III: Comparison of Three Trimesters of CAI and Title I Secondary Reading (Gates Comprehension Subtests)

Program	N	Grade	Pretest Mean G.E.	Posttest Mean G.E.	Adjusted Post G.E.	Gain
CAI	101	6	3.8	4.7	4.6*	.9
Title I						
Secondary	64	6	3.5	3.8	3.9*	.3
Reading					F = 30.4 F = .01	

* Differs Significantly

(Lysiak, 21, p. 70)

The Oakleaf Small Computer Project had as its major objective to individualize elementary mathematics instruction by using a fully-integrated system of CAI evaluation, and class management, based on the IPI Mathematics program. The project was an overall success, and additional lines of investigation are being pursued to determine if student aptitudes interact with the treatment; to develop a model of ideal problem solving in the program and to demonstrate that students will approach the ideal with experience. A study on these lines would clarify methodology for creating teaching sequences and help develop additional programs of a similar nature to broaden the scope of application. (Carlson, 6, p. 66)

The FUNTIONS program utilizes a problem solving environment to teach skills, stating the problem, gathering and organizing data, using feedback, subdividing the problem, integrating subsolutions, and knowing when the problem is finished. (Carlson, 6, p. 65) The program consists of 100 objectives and teaching sequences for use when teaching the program. After one year of continuous use, results showed that students achieved 88% mastery of the objectives and successfully transferred learnings to a paper and pencil test. Later program improvements increased the transfer rate to 90.3%. (Carlson, 6, p. 66)

> "The success of this one effort at combining the teaching of problem solving with the teaching of mathematics content suggests that other similar efforts should be undertaken." (Carlson, 6, p. 67)

The last CAI program we will study for which there is data is a program of the type of which this paper advocates. The Word Problem Program is a programmed sequence for teaching students to solve word problems. To evaluate the program fourth and fifth graders were selected randomly with the remaining students in the classes serving as controls. As a pretest all students were given the apropriate level of the Stanford Achievement Test.

The program was completed over an eleven week period in a total class time of four and one half hours. The computation and application sections of the Stanford Achievement tests were used as posttests. It is both significant and important that both the fourth and the fifth grade experimental groups showed a five month gain over the group receiving standard instruction (with a small time investment) in an area difficult to teach. Another interesting observation concerns the fact that the Applications subtest of the Stanford Achievement

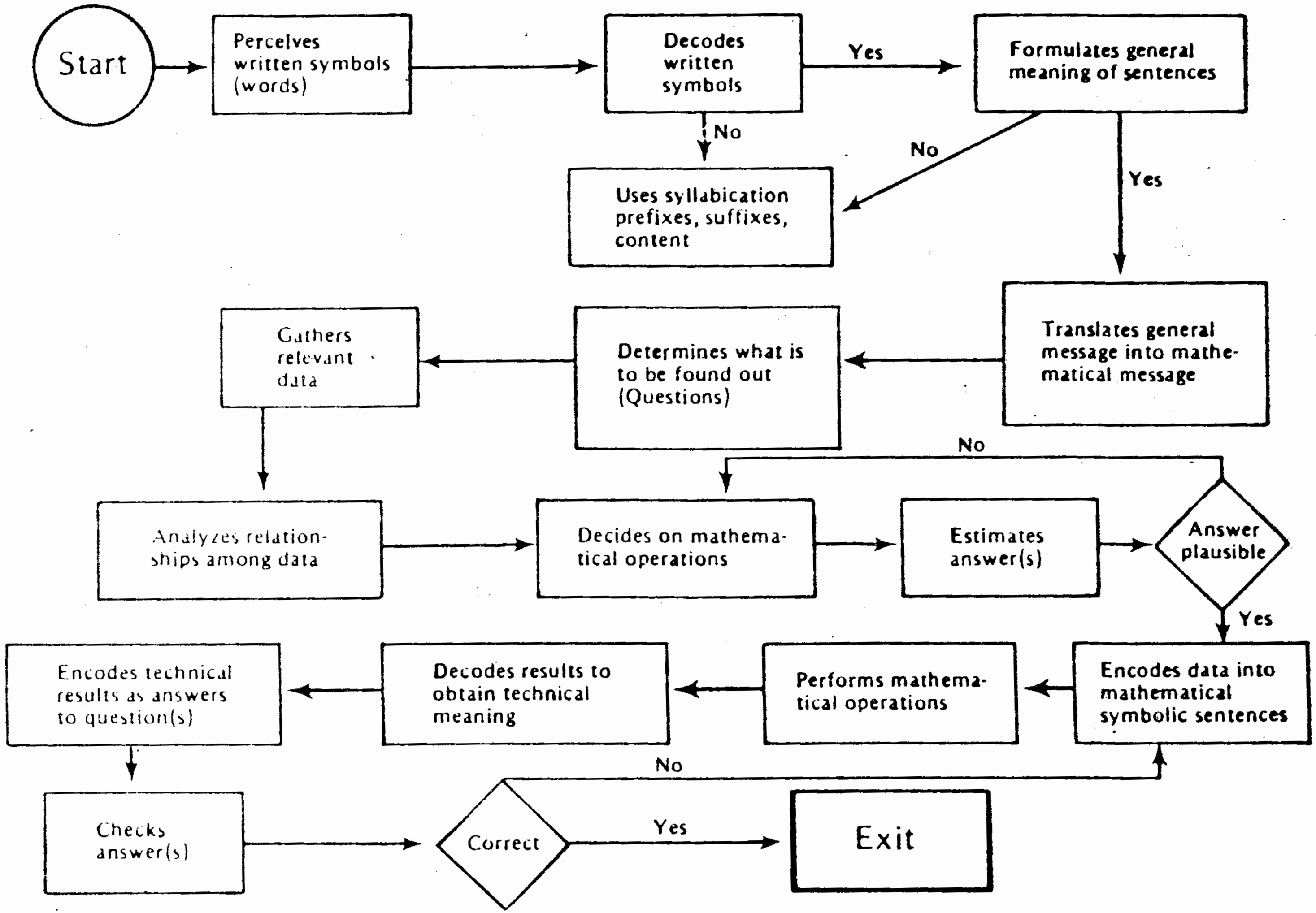
Test includes the concepts of money, time, fractions, percentage, and units of measurement (degrees, ounces, gallons). None of which were treated in the Word Problem Program. This occurrance seems to indicate a transfer effect from a carefully selected domain to a larger group of problems. It also implies that the fundamental problem solving skills taught in this program have generality beyond their initially limited scope. (Roman, 27, pp. 7-14) Most studies "available indicate that CAI is as good as, if not better than, traditional methods in terms of improving performance." (Lavin, 20, pp. 164-165)

> "Solving word problems is one of the major learning difficulties students in grades 1 through 8 have to face. The teacher of this combined reading, thinking, and computing process must analyze the minute, discrete steps required for successful solution, then evaluate the students' abilities to perform each step, and provide instruction where indicated. Students can be guided to think their way to understanding and solving word problems." (Dunlap, 9, p. 431)

In order to accomplish this feat, Dunlap and McKnight have developed fourteen steps for solving word problems. They go on to state that the mathematics teacher can guide and develop the thinking process by utilizing a hierarchy of questions asked (i.e.; recognition or recall, translation, application, analysis, and evaluation. (Dunlap, 9, pp. 440-441) (See Figure 1)

One of the stumbling blocks encountered by many students is the requirement by most teachers that each step be written down. This shows the teacher that the student has reached the solution logically

FIGURE 1
Flow Chart for Solving a Word Problem in Mathematics



(Dunlap, 9, p. 432)

or where the mistake was made, enabling the teacher to better assist the student. Most students find this task a drudge even though it is necessary. (Alderman, 1, p. 209)

> "When students solve a problem, they usually go through a number of steps before reaching the final solution. Sometimes these intermediate steps appear as part of a written solution. In·taking a classroom math test, for example, a student might be directed to show all work in order to receive full credit. But more often, as in multiple-choice tests, a student leaves no evidence to suggest the paths to a solution. This reflects our usual emphasis in education on the final solution or product from problem solving.
>
> If we want to know how a student goes about finding a solution to a problem, then our interest is in the process of problem solving. We would expect such an emphasis in cognitive psychology, where concern for thought and higher-order learning leads us to emphasize covert behavior. Process is highly relevant to educational psychology, since teaching problem solving might rationally parallel a students' own progress." (Alderman, 1, p. 209)

It is easy to see then, that while students may rebel against writing down each step (as every classroom teacher knows they will), it is highly important that the classroom teacher require that the students write down the steps they go through in finding their problem solutions.

Another challenge for the classroom teacher to meet is the difference in the rate of individual development. Even for children who have the same chronological age, the rate of mental development can be months apart. This creates a whole new series of challenges for the teacher who is trying to provide meaningful problem solving experiences for each child at his or her own level of understanding. (Weber-Garton, 37, pp. 5-6)

Not only does the classroom teacher have to consider the boredom factor (i.e., writing down each step) and the differences in individual development, s/he must also consider that children, as well as adults, display different styles of thinking.

> "Again, it is impossible to work with people for very long without discovering how distinctively different are their styles of thinking. In mathematics, there is an acknowledged difference between visualisers and symbolisers, teachers recognize convergent and divergent thinkers in their classes; people differ in operating by reflection or by impulse. None of these categories is, of course, distinct or self-contained, which makes coping with the differences in the classroom all the more difficult." (Burton, 5, p. 44) (See Table V)

There is yet another facet to consider when teaching story problem solving. The level of linguistic development of each student must also be considered. Since "mathematics is both linguistically dominated and a language in its own right," (Burton, 5, p. 46) it is vitally important that each student understand not only the linguistic meaning of words but the meaning of those words when they appear in mathematical

Table IV: Individual differences in the classroom

Individual differences
Developmental (pre-operational/concrete) (Piaget)
Mode of thinking (enactive/ikonic/symbolic) (Bruner)
Thinking style (visualiser/symboliser)
Preferred thinking pattern (convergent/divergent) (Guilford)
Understanding (instrumental/relational) (Skemp)
Thinking strategies (memory/pattern/operational) (Dienes)
Approach (impulsive/reflective) (Adams/Ault/Kagan/McKinney)
Attitude to learning mathematics (positive/negative)

(Burton, 5, p. 45)

context. Because mathematical language and the growth of mathematical understanding are closely allied and permeate the general linguistic development of children, it is important to the child's mathematical development that he learn both the correct use of mathematical language and learn to use mathematics itself correctly. Therefore, story problem solving is not only content based, but skill based as well. (Burton, 5, pp. 46-47) The implication here being that the classroom teacher has yet another facet of developmental difference for which to prepare.

When we consider the recommendations made for areas of emphasis and pitfalls to watch for when teaching story problem solving, certain suggestions and methods stand out as being of prime importance. Educators have long known that for learning to take place there must be interest generated. One way of generating interest is "to give students opportunities for developing and solving their own problems. This type of activity can help them to become actively involved in the process of mathematics inquiry. Whereas the problems that students choose to consider might not always be mathematically new, such problems can provide a unique setting for learning important mathematical facts and useful problem-solving skills." (Gathany, 15, p. 617)

What better way to stimulate interest than to seat the student at a microcomputer which contains a program which allows him to write his own story problem? As has been noted earlier, learning occurs and is enhanced when the student is actively involved in the process, "getting his hands dirty," so to speak.

"Problem solving is, sometimes, an individual activity but more often than not it is considerably aided by working in groups. It is not an activity which is fruitfully conducted as a teacher-led discussion. The first commitment required of teachers, therefore, is to allow the class this period of time to pursue a problem either individually or in small groups for as long as they find fruitful activity within it. Along the way, they can be reminded of the heuristics which they have already found useful." (Burton, 5, pp. 53-54)

When one contemplates the wide range of student abilities and the skills and concepts with which the classroom teacher must contend, microcomputers, with their ability to work tirelessly with an individual at whatever skill level s/he is, seem to be a viable answer. CAI has been on the educational scene since the early 1950's when the computer industry first used CAI programs to train their own personnel. CAI then moved into classrooms at all levels of education from the elementary to the university level and in subject matter ranging from arithemetic drill-and-practice, foreign languages, music, and health education to college physics courses. (Suppes, 35, pp. 9-11) With the advent of the microcomputer and certain technological developments, it has become possible for the classroom teacher to make use of this tireless assistant to provide a level of individualization not possible without another teacher or aide in the room.

The microcomputer lends itself perfectly to the type of instruction suggested earlier in this paper as being a desirable tool for learning story problem solving, particularly with intermediate grade students. (Gawronski, 16, p. 108) It can, in fact, provide a wide variety of independent instruction for students by assuming the role of teacher and presenting material in a programmed learning format, moving the student gradually from one step to the next at his or her own pace. The student is actively involved, receiving immediate feedback, and it is possible for some programs to monitor the student's progress and skip ahead or review material as needed. (Spivak, 31, pp. 84-85)

> "The primary advantage of the computer over other audio/visual devices is the automatic interaction and feedback that the computer can provide. Multiple paths through the course material can be taken, depending upon the individual student's progress." (Frenzel, 13, p. 86)
>
> "As a result, computer-aided instruction is no better or worse than other teaching techniques. Its main value is as an effective technique for individual rather than group instruction." (Frenzel, 14, p. 88)
>
> 'Most computer-aided instruction is interactive and fast-paced. Computers will not replace teachers, but will provide teachers with another tool to supplement and enhance education." (Frenzel, 13, p. 94)

Not only can CAI make it possible for the classroom teacher to more readily provide for the individuality of her/his students, but research suggests CAI can compress learning time with about equal retention, thus making possible a more efficient use of time. (Joiner, 19, p. 498) The branching structure, inherent in CAI, permits immediate review, remedial, or supplementary sequences to be provided based on the student's previous response. (Rudnick, 28, p. 37)

Using a microcomputer in the classroom can motivate students to think creatively to solve problems. Students can be taught to use the computer to solve problems they care about. Simulations of real situations, not normally possible in the classroom, can be done on the microcomputer. "The computer allows children and adults to address a whole new world of interesting problems that might be too tedious or dangerous to be solved by hand." (Souviney, 30, p. 58)

As has been suggested previously, the best way to teach solving story problems is to let students develop their own programs. To make this step, students must achieve computer literacy. Indeed, the achievement of computer literacy must be a goal of our educational system if it is to adequately prepare its students to meet the needs to tomorrow's computer oriented society. (Stahl, 33, p. 20)

> "There is a need for society to be educated and to know machines are to serve us, not be our masters." (UNI Century, 37, p. 1)

> "One of the most important teaching functions of computers in the schools will be the actual teaching about computers. As computers become more prevalent in society, it is important that members of society learn to work with computers. Exposure to computers of various sorts from an early age in the school system will not only cause people to use them routinely, but will mold their thinking to the logic of computer functions. In a very read sense, the illiterates of the next generation will not be those who cannot read, but those who cannot program computers and use their capabilities." (Gambrell, 14, p. 328)

In the past, computer use, particularly programming, has been limited to certain areas. It has been estimated that computer usage for instruction in all schools, secondary and elementary, approaches 50% with the majority of the instruction taking place in the secondary. In higher education, over half the students using computers fall in three areas: computer science, business, and engineering. (Malnar, 25, p. 26) Given the normal attrition experienced from elementary to secondary to higher institutions, this means many people illiterate concerning the computer. Our educational institutions are becoming gradually aware that they are not meeting the need for computer literacy. Indeed, being a computer illiterate in the near future may be as limiting to growth and productivity as being functionally illiterate in reading, writing, and arithmetic. (Molnar, 25, pp. 26-27).

"Our modern industrial society and its high standard of living is one result of language and literacy." (MacKinnon, 22, p. 33) By using the microcomputer to teach computer literacy through the investigation of the fundamental langauge of each computer, understanding the language of the computing process, information handling, assembly language, and its method of handling machine language commands, the intellect is challenged to recognize, compare, analyze, and synthesize. If we add computer literacy to the list of subjects taught in our educational institutions, we will have a society that will do its own thinking and use the computer as it is intended, a tool to enhance and improve our way of life. (MacKinnon, 22, p. 34)

Computers manifest themselves in many facets of our daily lives. We cash checks, pay bills, use a telephone, and do several other chores daily that involve the use of a computer at some point in the process. Computer technology is used in almost all aspects of business, social, cultural, and religious endeavor to improve and enhance the operational effectiveness and efficiency. (Gleason, 17, p. 14) Our educational institutions must address themselves to this challenge if they are to effectively prepare today's students to be tomorrow's citizens and leaders.

One way of developing computer literacy is to create modules which integrate both computing and regular mathematics or arithmetic courses. By using CAI to teach story problem solving and allowing each student to create his/her own problem, the classroom teacher can provide time for each student to spend time programming every day, thus developing both computer literacy and problem solving skills. (Gambrell, 14, p. 330) It is vitally important that education uses tools available today to prepare students to live at an optimum level in the near future. (David, 7, p. 20) One of those tools is the microcomputer. It can be used to assist and enhance the classroom teacher's instruction and, at the same time, to better prepare today's students to cope as citizens in tomorrow's society.

The question of the cost-effectiveness of CAI has been alluded to throughout this paper. It is a difficult topic to deal with ambiguously without a specific program in mind. We can, however, speak in a general manner about cost-effectiveness, CAI, and the microcomputer.

In the past CAI programs developed for use on a large computer with terminals in remote locations have been judged time and again to be cost effective.

"CAI may be the most cost-effective alternative for large-scale solution of this problem" (individualized instruction). (Fletcher, 12, p. 39)

The study on The Word Problem Program also found that CAI is a cost-effective way to present an individualized program. (Roman, 5, p. 13) It may also be worthy of note here that the Fletcher study was reporting on the use of CAI in beginning reading instruction and the Roman study was reporting on the use of CAI in instruction of solving story problems.

"Major computer companies themselves are designing training programs for their employees utilizing small micros as the most efficient, least costly method of accomplishing individualized and small group instruction." (Miller, 23, p. 34)

To put this statement in its proper perspective, one should note here that none of the major computer companies have entered the micro-computer market. The point being, their cost per unit for hardware and software would be approximately the same as any school system. Technologically, CAI is feasible for classroom use. (Splittberger, 30, p. 25) Programs exist for the large computers that have met with varying degrees of success. It seems that it would cost no more for programs to be written or purchased and the hardware acquired than it is to buy a new textbook series which should be replaced every five years, more or less. It also seems that it would be much less costly to update a computer program by changing a few sections than to buy new books. The available data suggests that the microcomputer is, and will become, increasingly more cost-effective as the technology continues to refine and improve.

There is evidence that individualized, self-paced instruction can effectively reduce the amount of instruction time needed. Evidence is also available that CAI permits the teacher to spend more time helping students individually. (Milner, 24, p. 15) Although it is difficult to place a dollar figure, it would seem that a more efficient and effective method of instruction is yet another factor to consider when determining cost-effectiveness.

Thus far in discussing cost-effectiveness, we have talked in terms of the kinds of figures which appear in an accountant's ledger. What about those items which are difficult to hang a price tag on? Learner motivation has always been a thorn in the side of any teacher. Use of the microcomputer makes it possible for students in a less restrictive environment through movement and interaction, rather than in a restricted and stifled one. When we compare the atmosphere in many classrooms to the natural environment in which one is free to move and interact with a variety of natural and manmade things, to classroom leaves much to be desired. A microcomputer provides the variety and interaction necessary to hold the interest of students who have lost interest in school, but still have a desire to learn. (Bell, 3, p. 16) In mathematics the novelty of using a CAI acts as an aid to learning and does not wear off quickly. In fact for some students it appears to hang on for months and even years. (Bell, 21, p. 431)

CAI and CMI have been used for the following tasks in the past:

"1. To present unfamiliar concepts and principles in an interactive textbook format to students at computer terminals.

2. To generate, administer, and score tests; to keep records; and to assist teachers with a variety of other ancillary activities in teaching.

3. To provide individualized tutoring to students.

4. To drill students on new skills and help them practice these skills.

5. To diagnose learning problems and error patterns and provide remedial instruction to children.

6. To help students learn algorithms for solving many types of exercises and problems.

7. To provide students with a means of exploring new concepts and principles and in some instances to promote learning through discovery.

8. To manage complex, multimedia learning environments.

9. To give students an additional measure of motivation to learn mathematics."

(Bell, 2, pp. 429-430)

In fact, over an increased period of time, CAI has been added to the curriculum with less than one percent in the instructional costs. (Bell, 2, p. 429)

Summary

In this literature review we have looked at research on the use of CAI in the elementary and secondary classroom and its relative success.

We have researched the need for more effective teaching methods in teaching story problem solving, the need for teaching computer literacy, and the cost effectiveness of the microcomputer. At its worst, CAI is no better or no worse than other more traditional methods, and, in most cases, shows greater gain than the more traditional methods. After showing the need and importance for improvement or change in traditional approaches to teaching story problem solving, we suggested that CAI using the microcomputer would be the most cost-effective way to accomplish this task and to begin teaching computer literacy, another need we have identified. In light of the research and the needs and future needs of society, it would seem that the use of the microcomputer and CAI in the elementary classroom in teaching story problem solving is worth further investigation. Other factors, such as the need for more cost-effective methods and a computer literate society, make the use of the microcomputer to teach story problem solving an even more worthy subject for serious consideration.

CHAPTER III: SUMMARY

Introduction to the Summary

It is the intent of this paper to show the need for increased use of the microcomputer in the classroom. To accomplish this, an attempt has been made to show the effectiveness of CAI in increasing student performance, improving student attitude, improving individualized instruction, and shortening instruction time. Investigations have been made into the need for more effective methods for teaching story problem solving and the need for computer literacy by tomorrow's citizens. We have shown that by using CAI to teach story problem solving, computer literacy can be achieved. An attempt has been made to show that by considering many factors the microcomputer is cost-effective and will become even more so in the future.

Summary

In the literature review we have first looked at research that suggests that the difficulties students encounter with story problems do not lie in the area of computation but in the realm of language and reading, and in needing an approach or plan of attack in order to find the solution.

We then look at research on the effectiveness of CAI in three areas; reading, basic computational drill, and problem solving including one study which deals with story problems in particular. The CAI programs research studied are those written for large centrally-located computers with remote terminals. The rationale for this being the relatively recent development of the microcomputer and programs for it and the lack of research done on the effectiveness of these programs. The author feels that because microcomputers possess most of the same capabilities as a large computer (the main difference is in size of stored memory) that the conclusions drawn from research on large computer CAI can be applied to microcomputers with a high degree of accuracy.

Research on CAI in the three areas mentioned earlier tends to show certain similarities which are significant. The first being the success factor of students involved. In almost every study the computer group showed a gain over the control group. The gain ranged from .3 of a year in one study to 4.2 months in another. Students using CAI were also able to successfully manage their own instruction. Another area in which CAI enjoyed considerable success was attitude improvement. Teachers in the programs reported more positive attitudes were shown by students not only in the CAI course but in other areas of school involvement. Less time was spent by students in CAI to learn the same content and there are indications that retention rate is higher for students using CAI as compared to traditional methods.

The wide variance in student abilities at the same grade level was discussed along with the need for provision of meaningful experiences at each student's level of understanding. The need in story problem solving for each student to write down his/her approach to finding the solution and the need for eliminating as much drudge work as possible was also discussed. Once again CAI can provide an answer to a thorny problem. CAI cannot only adjust to the needs of each individual student, but it can also keep track of each student's progress (i.e., areas of success and difficulty) for the teacher. But, because CAI moves the student logically, a step at a time, through its program, the need for the student to write down each step is eliminated.

Advantages of the computer over other audio-visual devices were also discussed. The fast pacing and the interaction possible between student and computer make it an invaluable assistant in the classroom. CAI also makes it possible for students to construct their own problems and solutions.

The need for computer literacy in today's computer-oriented society was discussed. The point was made that, because our society uses computers in almost every area of endeavor, it is important for its citizens to be literate with the computer. Today's citizen must be able to manipulate or, at least, understand that manipulation of a computer is possible. Otherwise, we become unable to direct our society's destiny and allow ourselves to be directed by a machine. Literacy is the responsibility of education and one of the ways to fulfill this responsibility is to use the microcomputer to not only teach students how to solve story problems, but teach them how to create and solve their own problems by teaching them how to program a computer!

Cost-effectiveness was also discussed. With technology moving forward by leaps and bounds, microcomputers cost much less today than they did five years ago, and are capable of even more refined tasks than before. When considered in light of time savings (discussed earlier), student attitude and success rate, and the need for teaching computer literacy, the microcomputer cannot be ignored. With publishing costs rising, we, in education, face the dilemma of having to replace textbooks at an ever increasing cost. Microcomputer programs, on the other hand, can be updated and changed for a comparatively low rate. One computer program can serve a whole classroom with ease. Can one textbook?

It is the feeling and observation of this researcher that the technological advances in computer science have far outstripped the ability of our educational system to make effective use of them. The computer is here to stay. It is a tool with limitless possibilities for use in the classroom. Recent developments in micro and space age circuitry have made it possible for the cost of microcomputers decrease and to continue to decrease. It is this development that makes it possible for the microcomputer to be considered realistically as a tool for the classroom teacher to use, not only in teaching story problem solving, but other areas as yet not yet considered.

Discussions and Conclusions

It would seem then, that given the success of CAI in providing for individualization, increasing academic achievement over a shorter time period, increasing retention rate, and improving student attitude, CAI should be carefully considered for more extensive use in the classroom. The technological improvements and the decreasing costs along with the ease of installation and operation make the microcomputer a logical choice. The need for computer literacy and the need for improvement in teaching story problem solving, argue strongly for the development of CAI programs which not only help the teacher teach problem solving, but allow the student to become familiar with computer operation and simple programming.

There is a great deal of discussion in educational periodicals about the use of the microcomputer in the classroom and the difficulty experienced by students in solving story problems. There is also ever increasing concern over the lack of a computer literate society. Part of the solution to all of these concerns lie in the increased use of the microcomputer in the classroom particularly in the area of story problem solving.

Limitations of the Study

Because of the nature of this study, it was necessary in many cases to rely on secondary sources. For this reason, some of the information may be inaccurate or incorrect due to misquoting or biased quoting by the secondary source. Primary source information has been used wherever available.

Implications for Further Research

It seems obvious from the research already conducted, the continuing decline in the cost of microcomputer, and the constant technological breakthroughs in computer technology that CAI must be considered seriously as an educational tool. In order to do this, the microcomputer must be placed in more and more classrooms so that research can be conducted on its effectiveness over a larger population than has been used in the past.

Implications for Future Use

This study can be used in several ways. It points out the need for increased emphasis on the teaching of story problem solving skills at the elementary level. It suggests that education at all levels need to look seriously at CAI in the classroom. Finally it indicates that educators need to consider the microcomputer as a tool, not only for drill-and-practice exercises, but as an aide or assistant to the classroom teacher, to support and augment, his/her efforts in the classroom. It suggests that it is time for education to join the computer generation in order to realize fully its goal of preparing our children as citizens of the future.

BIBLIOGRAPHY

1. Alderman, Donald L. "Tree Searching and Student Problem Solving," Journal of Educational Psychology, Vol. 70, No. 2 (1978), 209-219.

2. Bell, Federick H. "Can Computers Really Improve School Mathematics," Mathematics Teachers, 71:5, (May, 1978), 428-433.

3. Bell, Frederick H. "Why Is Computer-Related Learning So Successful?" Educational Technology, 19:12, (December, 1979), 15-18.

4. Blakeway, C. G. Drill, Practice, and Testing Applications for the Reluctant Learner and Teacher of Mathematics: Elementary and Secondary. Paper presented at the annual conference of The National Association of Users of Computer Applications to Learning, Portland, Oregon, 1976.

5. Burton, Leone. "The Teaching of Mathematics To Young Children Using A Problem Solving Approach," Educational Studies in Mathematics II, 11:2, (February, 1980), 43-58.

6. Carlson, Fitzhugh, Glaser, Hsi, Jacobson, Pingel, Puente, Roman, and Rosner. A Computer-Assisted Instructional System for Elementary Mathematics. Learning Research and Development Center. Pittsburgh University. 1974.

7. David, Austin. "Computer Assisted Instruction: Yesterday, Today and Tomorrow," Momentum, 9:5, (May, 1978), 16-20.

8. Dugdale, and Kibbey. Elementary Mathematics with PLATO. Coordinated Science Lab. Illinois University, 1977.

9. Dunlap, and McKnight. "Teaching Straegies for Solving Word Problems in Math," Academic Therapy, 15:4, (March, 1980), 431-441.

10. Education Commission of the States. 'Math Achievement in Plus and Minus." National Assessment of Educational Progress in Mathematics. NAEP Newsletter, 49:3, (November, 1979), 1-2.

11. Elsing, L. John. "Is Television Killing Our Schools?" The Lutheran Standard, (February, 1977), 12-13.

12. Fletcher, J. D. Computer Assisted Instruction in Beginning Reading: The Stanford Projects. Learning Research and Development Center. Pittsburgh University. (May, 1976)

13. Frenzel, Lou. "The Personal Computer - Last Chance for CAI?" Byte, 5:7, (July, 1980), 86-96.

14. Gambrell, and Sandfield. "Computers in the School: Too Much Too Soon?" The High School Journal, 62:5, (May, 1979), 327-331.

15. Gathany, Timothy A. "Involving Students in Problem Solving," Mathematics Teacher, 72:11, (November, 1979), 617-622.

16. Gawronski, Hendrickson, and Fehlen. "Computer Assisted Instruction in the Elementary School," School Science and Mathematics, 76:2, (February, 1976), 107-109.

17. Gleason, Gerald T. "Microcomputers in Education: The State of the Art," Educational Technology, 21:3, (March, 1981), 7-18.

18. Jacobson, Thompson, and Murray. Self-managed Learning Using CAI. Learning Research and Development Center. Pittsburgh University. 1975.

19. Joiner, Miller, and Silverstein. "Potential and Limite of Computers in Schools," Educational Leadership, 37:3, (March, 1980), 498-501.

20. Lavin, Bebe F. "Can Computer-Assisted Instruction Make a Difference?" Teaching Sociology, 7:2, (January, 1980), 163-179.

21. Lysiak, Wallace, and Evans. Computer Assisted Instruction. 1975-76 Evaluation Report. A Title I Program. Revised. Department of Research and Evaluation, Texas, 1976.

22. MacKinnon, Colin F. "Computer Literacy and the Future: Is It Possible to Prevent the Computer From Doing Our Thinking for Us?" Educational Technology, 20:12, (December, 1980), 33-34.

23. Merchant, Michael C. One Hundred Years of Arithmetic. Unpublished manuscript, 1976. (Available from RFD, 301 N. Buchanan Road Jesup, Iowa 50648.)

24. Miller, Inabeth. "The Micros Are Coming," Media and Methods, 16:4, (April, 1980), 32-34.

25. Milner, Stuart D. "How to Make the Right Decisions About Microcomputers," Instructional Innovator, 25:9, (September, 1980), 12-19.

26. Molnac, Andrew R. "The Coming of Computer Literacy: Are We Prepared For It?" Educational Technology, 21:1, (January, 1981), 26-28.

27. Morgan, Sangston, and Pokras. Evaluation of Computer-Assisted Instruction, 1975-76, Montgomery County Public Schools, Maryland, 1977.

28. Roman, Richard A. The Word Problem Program: Summative Evaluation. Learning Research and Development, Pittsburgh University. 1975.

29. Rudnick, Martin F. "Now You Can Program the Computer in English," Audiovisual Instruction, 24:4, (April, 1979), 36-37.

30. Slattow, G. (ed.) Demonstration of the PLATO IV Computer-Based Education System. Final Report. January 1, 1972-June 30, 1976. Computer-based Education Lab., Illinois University. 1977.

31. Souviney, Randall. "There's a Microcomputer in Your Future," Teacher, 97:2, (February, 1980), 53-58.

32. Spivak, and Varden. "Classrooms Make Friends with Computers," Instructor, 89:3, (March, 1980), 84-86.

33. Splittberger, Fred L. "Computer-Based Instruction: A Revolution in the Making?" Educational Technology, 19:1, (January, 1979), 20-26.

34. Stahl, Robert M. "Tomorrow's Education (Whether Your're Ready or Not)," Audiovisual Instructor, 24:11, (November, 1979), 20-21.

35. Stake, B. E. PLATO and Fourth Grade Mathematics. Paper presented at the annual meeting of American Educational Research Association, Canada, 1978.

36. Suppes and Macken. "The Historic Path From Research and Development to Operational Use of CAI," Educational Technology, 71:4, (April, 1978), 9-12.

37. "UNIKIT-A Tale of Tinker Toys and Computers," The UNI Century, 5:2.

38. Weber-Garton, Mildred Ann. Problems In Reading Elementary Mathematics Story Problems. Unpublished Manuscript. (Available at Curriculum Laboratory, University of Northern Iowa.) 1973.

39. Wells, Whilchel, and Jamison. _The Impact of Varying Levels of Computer-Assisted Instruction on the Academic Performance of Disadvantaged Students_. Research Bulletin. Education Testing Service, New Jersey, 1974.