Computer Assisted Instruction
WITH LEARNING DISABLED STUDENTS

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Sixth grade student practices division skills.

Background

Computer use in education has spanned well over two decades. First generation computer-assisted instruction (CAI) systems were developed in the late 1950s when computer technology was viewed as a vehicle for implementing the ultimate in programmed instruction (Baker, 1978). At that time, computer technology was considered by some to be *the* solution to major educational problems, and revolutionary changes in education were confidently predicted.

Revolutionary promises put forth by early proponents of computer education remain largely unfulfilled today (Splittgerber, 1979). Early CAI was delivered via large, centrally located mainframe computers that were often characterized by high cost and low reliability. Response time on these systems was frequently maddeningly slow as the number of users increased, and suitable courseware was difficult to obtain.

When combined with a lack of overwhelming evidence supporting the superiority of CAI over other instructional methods (Baker, 1978), these factors resulted in a general lack of CAI acceptance by the educational community.

Advances in Microelectronics

The explosion of microcomputers onto the educational scene has revived the previously unfulfilled promises of a technological revolution in education. The two major problems discovered during the past decades - high cost and low reliability - have been overcome by advances in microelectronics.

Consequently, predictions concerning the future role of microcomputers in education can only be described as roseate. The expectations of many educators are clearly conveyed by such publication titles as "Microcomputers and Education: Planning for the Coming Revolution in the Classroom" (Dickerson & Pritchard, 1981).

Major Impediments

However, major impediments to widespread adoption of microcomputers in education still exist. Foremost is the scarcity of good educational software (Scandura, 1981; Gleason, 1981). Another major barrier is the lack of evidence concerning the effectiveness of computer-assisted instruction.

Articles dealing with CAI have often been based upon speculation and conjecture rather than upon sound empirical research (Atkinson, 1968). As summarized by Thompson (1980), "numerous examples of computer usage can be cited, possibilities and capabilities far outweigh existing practices" (p. 38). Even when data were reported, serious methodological flaws often threatened both internal and external validity of results (Huntington, 1979).

A final and often overlooked barrier to the acceptance and widespread diffusion of technological innovations, including microcomputers, lies in the complex human dynamics of schools. Tyler (1980) cogently discussed the results of faulty assumptions concerning important psychodynamics in the schools. A teacher survey conducted by Stevens (1980), which found about half of the surveyed teachers not interested in computer training, clearly displayed the scope of these barriers to organizational change.

The remarks of a teacher, quoted in the NEA Reporter (1980), are even more graphically illustrative of this problem. "Every ten years or so there's something new in educational technology that's touted as a panacea," she stated. "A few years back it was instructional television and machine learning; now it's microcomputers. Once the newness of the gadget wears off, we return to the basic need for teacher-student interaction" (p. 11).

It is apparent from such survey and interview results that potent human dynamic factors must be considered and overcome before widespread adoption of microcomputers in education occurs.

Effectiveness of CAI

Overcoming the lack of good educational software is intimately related to the lack of conclusive evidence regarding the effectiveness of CAI. Good instructional software is a necessary, but not sufficient, condition for a valid test of CAI. Caldwell and Rizza (1979) have identified the following six criteria for instructional software design:

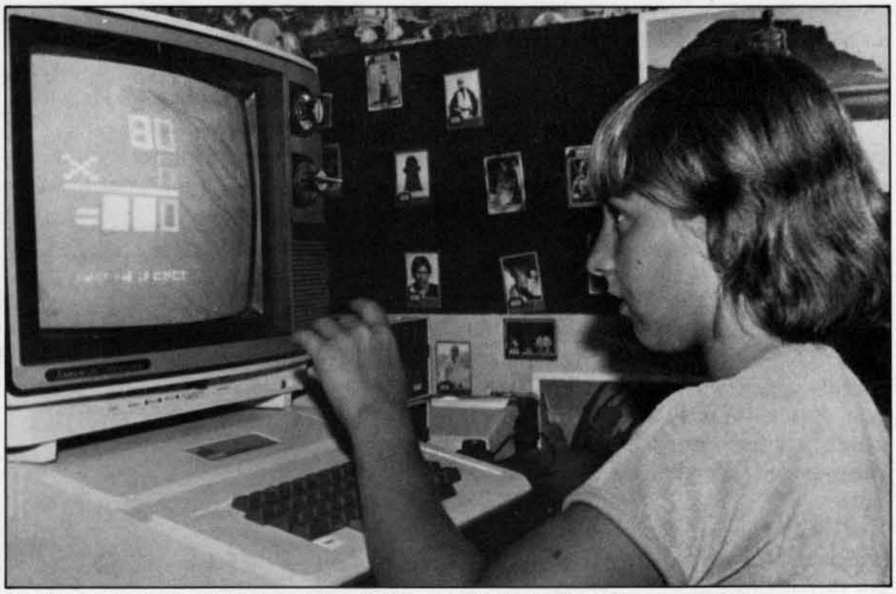
(1) Individualized with immediate and frequent feedback to learner responses.

(2) Comprehensive curriculum organized into a hierarchy of skills.
(3) Intended learner outcomes articulated in terms of performance objectives.
(4) Progress measured by mastery of performance objectives.
(5) Diagnostic and prescriptive strategies utilized to place learner appropriately within the curriculum.
(6) Employment of a multi-sensory learning format.

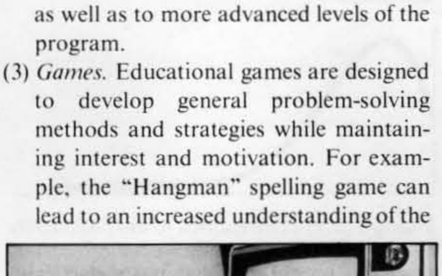
These criteria, combined with other educational and psychological principles, provide a solid context within which a judgment concerning instructional software quality can be rendered.

Educational software differs in method or mode of delivery as well as in quality. Consequently, mode of delivery is an important factor when considering the effectiveness of CAI. Six modes are commonly delineated:

(1) *Drill and Practice.* This mode is currently the most common use of computers in education. It is designed to integrate and consolidate previously learned material via computer practice and is a supplement to regular instruction.
(2) *Tutorial.* The tutorial program assumes the role of teacher and presents the material in a programmed learning format. The student moves from one step to the next by answering questions and may be branched to remedial or review segments as well as to more advanced levels of the program.
(3) *Games.* Educational games are designed to develop general problem-solving methods and strategies while maintaining interest and motivation. For example, the "Hangman" spelling game can lead to an increased understanding of the relative probability of the occurrence of vowels and consonants in English words.
(4) *Simulations.* This mode attempts to model the underlying characteristics of a real phenomenon so that its properties can be studied. Simulations may incorporate many of the features of games, but they are intended to more authentically model reality. For example, the simulation of a nuclear reactor can realistically portray the operation, and perils, of a modern electrical generating station.
(5) *Problem Solving.* Using the computer to solve real-world problems is the focus of this educational mode. Students may write computer programs to test possible solutions to a variety of real problems.
(6) *Computer Managed Instruction.* CMI allows the teacher to use the computer as a tool in diagnostic, prescriptive, and evaluative tasks. In this mode, student test scores might be utilized by the computer to generate future tests, prescriptions and grades.



Fourth grade student tries a multiplication problem that requires regrouping.



First grade student attempts a difficult addition problem.

Although other instructional modes will undoubtedly develop in the coming years, these six modes are presently most germane to microcomputer-based instruction. The drill and practice mode has received the most usage in education, and consequently a data base concerning its effectiveness has accumulated over the past decade.

Vinsohaler and Bass (1972) reviewed ten major drill and practice studies and concluded that "the effectiveness of CAI over traditional instruction seems to be a reasonably well-established fact in drill and practice for both mathematics and language arts" (p. 31). However, the advantages of CAI over other less expensive methods for augmenting traditional instruction and the long-term effects of CAI were not resolved.

Jamison, Suppes, and Wells (1974) opined that "at the elementary school level, CAI is apparently effective as a supplement to regular instruction...at the secondary school and college levels, a conservative conclusion is that CAI is about as effective as traditional instruction when it is used as a replacement" (p. 55).

Edwards *et al.*, (1975) reviewed the CAI literature and concluded that normal instruction supplemented by CAI was consistently more effective than other modes. From this compendium of data it seems reasonable to judge that CAI drill and practice has been marginally effective as a supplement to regular instruction with a variety of learners.

Negative research findings, lack of long-term data, dearth of comparative studies, and general inadequacy of the field preclude a more positive judgment. No conclusion regarding the relative effectiveness of the other five modes of instruction can be confidently reached due to paucity of data.

A diverse sample of educational software was represented in this survey of CAI research. However, software was generally not described in enough detail to enable the reader to make a reasonable determination of its quality. Without quality assurance, the marginally effective "grade" given to CAI drill and practice may be attributable to poor software rather than to inherent CAI weaknesses.

An additional unknown factor in the judgment of CAI effectiveness is the type of learner. It is possible that one population (i.e. elementary school, handicapped, adult, college, etc.) might receive radically different benefits from CAI than another. Discrimination of benefits by learner type cannot presently be accomplished due to insufficient evidence. However, it is clearly an important variable to be considered in any CAI investigation.

It is evident from the foregoing discussion that a valid test of CAI effectiveness must include three vital components:
(1) A clear delineation of delivery mode.
(2) An unambigious determination of instructional software quality.
(3) A clear description of the learners.

The remainder of this article is devoted to an evaluation of CAI drill and practice with good instructional software within a learning disabled population.

Subjects

Children who participated in this investigation were drawn from the population of elementary school aged learning disabled (LD) students enrolled in a suburban Southwestern school district. All participants were diagnosed as learning disabled by certified school psychologists, with the primary diagnostic criterion being a significant discrepancy between ability and academic achievement in the absence of environmental, health and emotional problems.

The CAI group was composed of 28 students (21 male and 7 female) in grades one through six (Mean = 3.61) who received math CAI. The control group, another 28 LD students matched by sex and enrolled in grades one through six (Mean = 3.64), received traditional special education services in math.

Apparatus

CAI students received math instruction on Apple microcomputers. Each CAI station consisted of an Apple II microcomputer, one disk drive, a color television monitor, and a thermal printer. Math CAI software was The Math Machine (1981), a drill and practice package that incorporated previously discussed criteria of instructional design (Caldwell & Rizza, 1979) as well as teacher-controlled schedules of reinforcement and record keeping systems.

A sequence of over 110 performance objectives covering pre-math through division skills allowed teachers to prescribe for students within a mastery learning paradigm.

Procedure

In September, the math computation section of the California Achievement Test (CAT) was administered to both the CAI and control groups. CAT test booklets were hand scored and raw scores were converted to normal curve equivalent (NCE) scores. NCE scores, which are normalized standard scores with a mean of 50 and a standard deviation of 21, served as a measure of pre-experimental math skill.

Each student's ability was estimated by the Wechsler Intelligence Scale for Children-Revised (WISC-R) full-scale IQ score (Mean = 100, Standard Deviation = 15). Full-scale IQ scores were extracted from educational records.

Post-testing with The Math H.E.L.P. (Bitter, Engelhardt & Wiebe, 1977), a criterion referenced mathematics test, was accomplished in February. This instrument covered addition through division skills with a hierarchical series of 68 test items. Math H.E.L.P. raw scores served as a measure of post-experimental math skill.

Table 1 presents descriptive statistics for pre- and post-experimental measures for both groups of students.

Table 1

Pre- and Post-Experimental Measures by Group

	MEAN			STANDARD DEVIATION		
Group	CAT	IQ	H.E.L.P.	CAT	IQ	H.E.L.P.
CAI	20.75	91.4	31.89	16.4	12.4	15.6
Control	27.43	93.3	25.64	13.8	11.2	10.9

Instruction for all 56 students was conducted in special education classrooms under the supervision of certified special education teachers. All CAI students received ten minutes of math CAI each school day in place of ten minutes of traditional instruction. Control group students received no CAI exposure and were limited to receiving only traditional special education instruction.

Results

A review of Table 1 indicates that the control group's pre-experimental math skills (CAT) and ability scores (IQ) were superior to the CAI group. Consequently, data analysis was accomplished via analysis of covariance to provide a statistical equation of the two groups before experimental training began. In this analysis, group membership was the independent variable, while IQ and CAT scores were covariates. Math H.E.L.P. scores were the dependent variable.

Results of this analysis of covariance indicated that students who received math CAI in place of the usual special education math achieved significantly greater post-test scores than did students who received only traditional special education services ($F = 3.94$; $df = 1.52$; $p < 0.05$).

An F value of 3.94 is graphically illustrated in Figure 1. For groups of the size used in this investigation, a difference in adjusted Math H.E.L.P. scores of this magnitude would occur by chance less than 5 out of 1000 times. Thus, it is reasonable to conclude that the present results are due to the computer-assisted instruction in math.

Discussion

Present results are very promising given that previous investigations with Learning Disabled students have failed to support the effectiveness of CAI. Chiang's (1978) elementary school LD students demonstrated a non-significant improvement in math skills when compared to a non-CAI control group.

Sandals (1979) reported non-significant comparative gains for math and spelling CAI with junior high school pupils who exhibited a wide variety of learning problems. Both investigations were methodologically flawed and both failed to adequately specify the quality of instructional software. These two factors, and the dearth of CAI research, suggest that it is premature to judge the effectiveness of CAI with LD students.

Figure 1. Probability Values of the F Distribution.

Shaded area corresponds to the probability that the difference in adjusted Math scores occurred by chance. The unshaded area represents the probability that such a difference was due to the CAI treatment.

However, the present positive results provide quantitative support for Thorkidsen and Williams' (1980) conclusion that computer technology will be applied to the needs of the handicapped with an increased frequency in the very near future. It is imperative that this growth in computer applications be guided by empirical evidence and systematic evaluation programs. □

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