

Computer Assisted Instruction at Stanford

Patrick Suppes
and
Max Jerman

Since January, 1963, the Institute for Mathematical Studies in the Social Sciences at Stanford University has been conducting a program of research and development in computer assisted instruction. For a review of the early work in CAI conducted at Stanford University, see Chapter 1 of Suppes, Jerman and Brian (1968). Currently, both tutorial and drill-and-practice programs are in operation in the areas of elementary mathematics, logic and algebra, spelling, beginning reading, and elementary Russian at the college level. A brief description of the programs now in operation in each area follows.

Tutorial programs

The logic and algebra program is a three-year sequence. Last year, 195 students completed the first year of the sequence, and two students completed both the first and second years. Students who completed the first year are continuing with the second-year course this year. Others are beginning the first and third year.

The student terminal is a teletype machine located in the school building. Each teletype terminal is connected by telephone line to a computer complex on the Stanford campus. **Figure 1** shows the system configuration and lists the number of terminals for Kentucky, Mississippi, Tennessee, San Francisco, and Ravenswood, California. Logic and algebra lessons are given at all locations except

Ravenswood, San Francisco, and a few local schools. This is the only program aimed mainly at very bright students and is offered as a supplement or enrichment to the regular mathematics program beginning at grade 5.

In September, 1967, 30 students at Stanford University enrolled in a course of computer-based elementary Russian for credit. The control class received regular classroom instruction, attended the language laboratory, and submitted written homework assignments. In the computer-based class, regular classroom instruction was eliminated and work at Model-35 teletypes with Cyrillic keyboard and audiotapes with earphones was substituted. Students received instruction at the computer-based terminals for a period of 50 minutes per day, five days a week, throughout the entire academic year.

At the end of the first year, the computer-based students performed at a statistically significantly higher level. Perhaps equally as important as the superior performance was a smaller drop-out rate for the computer-based section than for the regularly taught sections of the course.

The first-year program has been revised and a second-year course written. Both are now in operation, with 41 first-year and 19 second-year students enrolled.

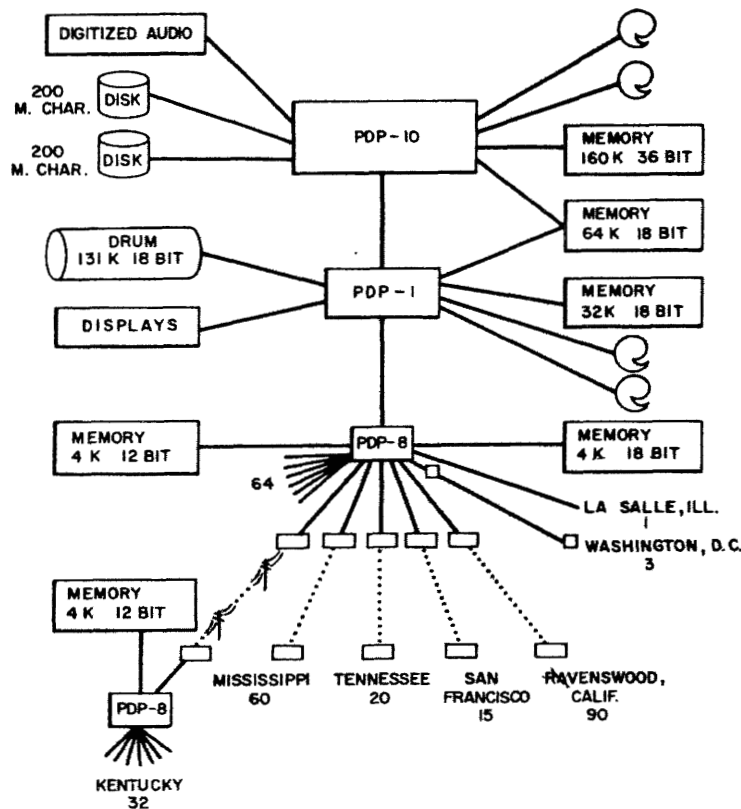
Drill-and-practice programs

During the 1967-68 school year, 3,823 students enrolled in 31 elementary and junior high schools completed nearly 300,000 arithmetic lessons. The curriculum, prepared for grades 1 to 6, consisted of approximately 13,600 individual lessons, reviews and tests which were organized into units. Each unit emphasized a particular skill or

This article is part of the current series on leading centers of activity in computer assisted instruction.

Patrick Suppes is professor of philosophy, statistics and education, and Max Jerman is research associate, Institute for Mathematical Studies in the Social Sciences, Stanford University.

Figure 1
System configuration.



concept, such as addition, fractions, or inequalities. Within each unit, lessons are arranged in five different levels of difficulty. This program has been described in detail elsewhere (Suppes, Jerman, Brian, 1968). All the topics normally included in the mathematics curriculum, with the exception of geometry, are included in this program.

Students in this program have shown statistically significant gains in achievement in computational skills over control groups. A summary of the 1967-68 program is given in **Table 1**.

The program is designed to supplement classroom instruction by providing individualized practice on basic skills and concepts after they have been introduced by the classroom teacher.

A drill-and-practice program in elementary reading is scheduled to begin this winter. First-, second-, and third-grade students will be given audio instructions over earphones and will respond on the teletype keyboard. Audio messages will be given by means of a computer-generated speech device, shown as digitized audio in **Figure 1**. Forty student

stations in the Ravenswood district will be equipped with earphones. The children will receive audio instructions and be able to respond simultaneously. (For a description of the computer-based programs in reading see Atkinson, 1968; Atkinson & Wilson, 1968.)

As the installation of telephone lines is completed, the average number of students processed daily in arithmetic, logic and algebra, and reading is expected to be approximately 8,000. Currently, approximately 2,500 students are receiving daily lessons in arithmetic and algebra and another 61 are receiving daily Russian lessons.

Programs under development

In addition to the above, two tutorial programs are being prepared for high school students in a San Francisco school. These programs are to teach computer programming.

A special set of lessons has been prepared for use with the Math 111 course for entering freshmen at Tennessee A. and I. State University at

Nashville, Tennessee. Math 111 is the first course of a three-course sequence for students who lack sufficient background to enter the regular calculus sections at the university.

In addition to a review of the basic arithmetic operations, the 13 curriculum units include work on factoring polynomials and simplification of simple algebraic expressions and complex fractions.

Students will spend 20 minutes each day in the classroom and 20 minutes at instructional terminals which will be housed in a recently completed portable building.

The most significant new program under development, from our point of view, is the complete reorganization of the elementary arithmetic sequence into a strands approach. Problems are arranged sequentially by concept, such as vertical addition, horizontal addition, vertical subtraction, fractions, decimals, and measurement in terms of the logical development of the total curriculum and the relative difficulty of the individual items. Lessons, as such, are no longer stored in the computer's memory. Rather, the rules for generating each type of problem in each strand are stored and used on line to compose each student's lesson individually by generating appropriate problems in each strand according to the student's performance. We believe this will be a significant step in truly individualizing instruction. This program is nearly completed and is expected to begin operation this month.

A second new program in arithmetic is one which emphasizes problem solving. Students will be given a word-problem statement. The numbers

in the problem will be labeled. For example, a problem statement may include three numbers. Following the problem statement the program would type something like:

$$A = 475$$

$$B = 892$$

$$C = 754.$$

The student commands the computer to perform operations by typing a simple statement, such as: $A + B =$, to which the machine responds $D = 1367$. Any operation is permitted, and standard functions, such as SQRT, SIN and COS, are available. The student is free to employ any sequence of steps to arrive at a solution. To indicate he believes he has a solution, a student types a colon after a command. At that point his solution is evaluated. Every student's strategy will become part of the data. The possibility of gaining further insights into problem-solving skills should be significantly increased. □

References

- Atkinson, R. C. Computerized instruction and the learning process. *American Psychologist*, 1968, **23**, 225-239.
- Atkinson, R. C., & Wilson, H. A. Computer-assisted instruction. *Science*, 1968, **162**, 73-77.
- Suppes, P., Jerman, M., & Brian, D. *Computer-assisted Instruction: Stanford's 1965-66 Arithmetic Program*. New York: Academic Press, 1968. Pp. 1-15.

Table 1

Stanford 1967-68 Programs in Computer Assisted Instruction
(The number of students shown is for May 15, 1968)

Program	Number of students		Terminals
	Jan.	May	
Drill-and-practice Mathematics, Grades 1-8			
California	985	1,441	TTY*
Kentucky	810	1,632	TTY
Mississippi	592	640	TTY
Tutorial Mathematics, Grade 2	76	76	CRT† + Audio + Film
Tutorial Reading, Grade 1	73	73	CRT + Audio + Film
Tutorial Logic and Algebra, Grades 5-8	195	195	TTY
Tutorial Russian, University level	30	30	TTY + Audio (Cyrillic keyboard)
Dial-a-Drill	15	15	Telephone

*Teletype

†Cathode-ray tube