COMPUTER-ASSISTED INSTRUCTION PROGRAM:

TENNESSEE STATE UNIVERSITY*

by

Barbara Searle, Paul Lorton, Jr., Adele Goldberg,
and Patrick Suppes

and

Nancy Ledet and Clinton Jones
Tennessee State University

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INSTITUTE FOR MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES

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INTRODUCTION

The computer-assisted instruction (CAI) program at Tennessee State University (TSU), in cooperation with the Institute for Mathematical Studies in the Social Sciences (IMSSS) at Stanford University and the National Science Foundation, was in operation from April 4 to July 31, 1972. For a previous period, 1968-70, TSU had had a joint CAI project with Stanford University, and as part of that National Science Foundation project, equipment had been purchased that in the spring of 1972 was still available and operational at TSU. The 1972 project was undertaken to complete the earlier project and to reactivate the cooperative program of the two institutions.

The CAI courses used were:

Basic English
Algebra
Computer Programming: BASIC
Symbolic Logic.

The following supplementary programs were also available:

Spanish Vocabulary Drill
"Hangman," a vocabulary game
Spelling Drill.

In addition to regular CAI classes, students, teachers and visitors made use of the courses and supplementary programs.

THE CAI LABORATORY

The CAI project used 20 teletypewriters housed in a separate portable building on the TSU campus. A diagram of the Laboratory building, showing the arrangement of terminals and other equipment, is shown in Figure 1. The terminals were connected to the IMSSS PDP-10 computer by phone line,

Insert Figure 1 here

with a PDP-8 computer at the TSU site serving as a multiplexing device. A detailed description of the hardware configuration used for communicating with Stanford is presented in Appendix 1. During the spring and summer of 1972 the Laboratory was open from 8:00 a.m. to 5:00 p.m. weekdays. The operation of the Laboratory was supervised by Professor Nancy Ledet, who served also as proctor.

CAI COURSES

Four CAI courses were used during the Spring and Summer Quarters. They are described briefly here.

Basic English: The Basic English course enables the student to recognize and correct gross errors commonly made in expository writing. The program deals with run-on sentences, sentence fragments, incorrect principal parts of verbs, confusion of adjectives and adverbs, lack of agreement between subject and verb, lack of agreement between a pronoun and its antecedent, incorrect case of pronouns, vague or indefinite pronominal reference, dangling elements,

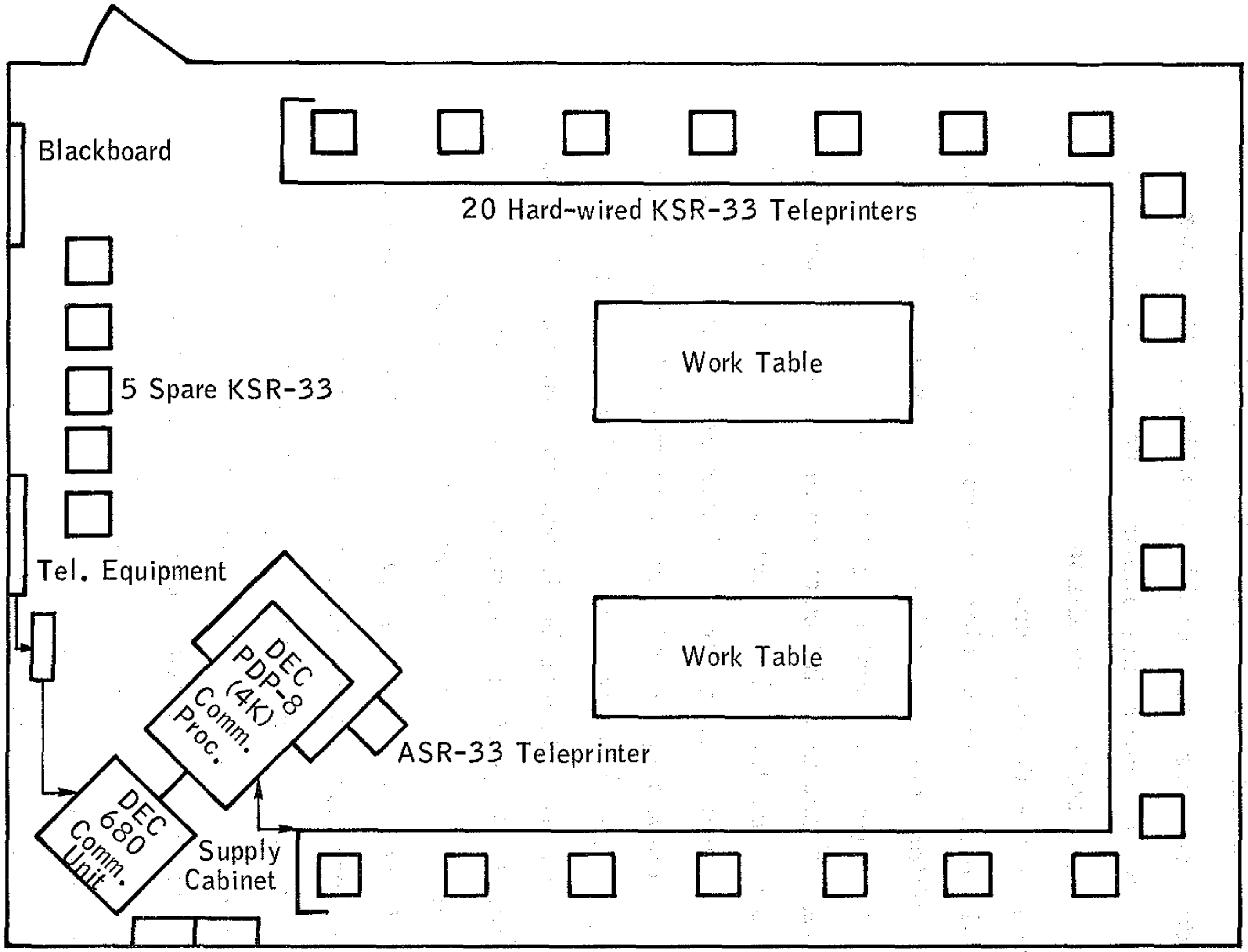

Figure 1. Layout of CAI Laboratory, Tennessee State University.

misplaced modifiers, errors in comparative forms of adjectives, adverbs and double negatives. The course was developed by Computer Curriculum Corporation in Palo Alto for use with college students and was used with the permission of the Corporation.

Algebra: The Algebra course contains three parts, each of which can be taken independently. Each part presents an aspect of elementary mathematics.

Part 1 provides instruction and drill in fundamental computational skills. The course is organized into eight strands covering addition, subtraction, multiplication, division, equations, fractions, measurement, and decimals. A student's lessons consist of problems chosen by the computer from the strands he is working on, at a difficulty level determined by his performance on each type of exercise.

Part 2 contains arithmetic word problems. The student learns a set of simple commands that allow him to tell the computer which computations to carry out. Most of the commands are given in the form of algebraic expressions. The task of the student is to work out a method for solving the problems and to instruct the computer which computations to carry out. Thus, the course focuses on problem-solving skills and the use of algebraic notation.

The main thrust of Part 3 is to teach the student skills in constructing mathematically valid proofs. The student is taught a command language with which he can construct proofs and find counterexamples about number sentences.

The three parts of the Algebra course are described in detail in Appendix 2.

Computer Programming in BASIC: The BASIC course teaches students the fundamental concepts of computer programming and how to write simple programs in BASIC, a higher level interpretive computer language widely used in applications programming. The course covers the following concepts of programming and uses of computers: an interactive timesharing executive system, an interpreter, a stored program, debugging techniques, labels and variables, loops (including nested loops), input and output, and subroutines. The student interacts with an instructional program and also communicates directly with the BASIC interpreter, writing programs which he may store in files allocated to him.

Symbolic Logic: This course introduces numeric variables forming algebraic terms and sentences, and truth conditions of simple algebraic sentences. The logical connectives, as well as an analysis of the truth values of compound sentences, are presented. At the time each connective is introduced the rules of derivation appropriate to it are also presented. The student must construct logical derivations using these inference rules. In addition to the rules of logic the student learns and uses rules, axioms and theorems about algebraic properties. Several lessons are devoted to the concepts of validity of rules and validity of arguments.

THE CLASSES

The CAI Laboratory was used by seven classes during the Spring Quarter and four classes during the Summer Quarter. Student enrollment is shown in Table 1.

Insert Table 1 here

For each class enrolled the Laboratory was used as a supplement to regular class activities. Each class was assigned one hour per week in the Laboratory during Spring Quarter and two hours per week during Summer Session. For both quarters students were allowed to work additional hours at the terminals if they so desired. Teachers made it known to their students that work in the Laboratory was part of the course requirement. Some of the English teachers required students to spend a minimum number of hours at the terminals. Algebra and BASIC Computer Language students were required to complete a minimum number of lessons. This worked out well, since students were able to make up laboratory absences at other than assigned hours. During the Spring Quarter the Algebra class used only the third part of the course. These students were enrolled in Mathematics III, Introduction to College Mathematics.

One of the BASIC Computer Language classes was a group of students enrolled in a FORTRAN Language course. By making use of the Laboratory, students finished the course with some knowledge of both FORTRAN and BASIC. Part of their final examination was to write and execute a program in

TABLE 1

Class Enrollments in CAI at Tennessee State University

Spring Quarter 1972

Course	No. of students	Teacher
Basic English	41	Miss Gloria Johnson
Basic English	12	Miss Helen Houston
Basic English	23	Mrs. Tyree Miller
Basic English	26*	Mrs. Nancy Ledet
Algebra	43	Frank Orndorff
Basic Computer Language	18	Clinton Jones
Basic Computer Language	10	Andrew R. Johnson

TOTAL NUMBER OF STUDENTS ENROLLED — 173

Summer Quarter 1972

Basic English	23	Mrs. Tyree Miller
Basic English	23	Mrs. Doris Daniels
Symbolic Logic	25**	Dr.Sadie Gasaway
Algebra	82***	Mrs. Nancy Ledet

TOTAL NUMBER OF STUDENTS ENROLLED — 153

* Special senior class
** National Science Foundation Institute
*** Upperbound Program

BASIC. The other class was a group of freshmen in an engineering orientation class. The instructor used the CAI Laboratory as a means of introducing students to computers and to a computer language.

A group of seniors who had failed a required English comprehensive test made use of the CAI English course. Unfortunately, these students did not repeat the test; if they had, the two sets of scores might have provided some worthwhile results. The other English classes were made up of students enrolled in either English 101, 102, or 103, Freshman English courses.

The CAI Laboratory serviced two special groups of students who were enrolled in summer programs at the University:

1. The Upperbound Progam, a program for eleventh- and twelfth-grade high school students, and

2. The NSF Institute in Mathematics for Junior High School Teachers.

The Upperbound students were enrolled in Algebra. They started with the first part of the course, arithmetic skills, and a few did some lessons in the second or third part. The NSF Institute students were enrolled in Symbolic Logic.

Table 2 shows the computer usage for the Spring Quarter. Data reported for the period from April 4 to May 31

Insert Table 2 here

TABLE 2

Computer Usage at Tennessee State Univeristy

Course	Number of sign ons	Total time in hours	Average session length in minutes
Basic English	804	441.7	33.0
Programming: BASIC	385	187.3	29.2
Algebra	315	93.8	17.9
Logic	35	10.2	17.5
Hangman	90	23.1	15.4
Spelling	27	4.1	9.2
Spanish	8	1.8	13.8
Total	1664	762.0	

cover four courses and three supplementary programs. The table shows the total number of sign ons, total usage in hours, and average session time. A total of 762 hours of CAI were logged during the period monitored. Due to system problems, such a report was not available for the Summer Quarter.

EVALUATION

We feel that a fair evaluation of the effectiveness of the CAI program would require a year's operation. However efforts were made to get some feedback about the program from students and teachers. At the end of the Spring Quarter, evaluation forms were given to students and teachers. The forms are contained in Appendix 3. Respondents were asked to use a 7-point attitude scale that ranged from Strongly Agree (1) to Disagree (7). Student evaluations were tallied, first by students in each course and then by all students. A total of 112 students and 5 teachers filled out forms. The results for students are shown in Table 3,

Insert Table 3 here

which contains the number and the percentage of students responding with each scale value to the 13 questions in the questionnaire.

For English students, evaluation items 3, 8, 9, 10, 11, and 13 had percentages greater than 50 for 1 on the scale. This indicates that over half of the students

TABLE 3

Attitude Questionnaire Data Analysis
Number and Percentage of Students Responding to Scale

Question number	Scale	English		Algebra		Basic		All	
		Type of Student							
1									
	0	0	.00	0	.00	0	.00	0	.00
	1	27	42.86	13	46.43	9	42.86	49	43.75
	2	16	25.40	9	32.14	5	23.81	30	26.79
	3	10	15.87	3	10.71	2	9.52	15	13.39
	4	3	4.76	1	3.57	0	.00	4	3.57
	5	2	3.17	1	3.57	2	9.52	5	4.46
	6	1	1.59	0	.00	1	4.76	2	1.79
	7	4	6.35	1	3.57	2	9.52	7	6.25
2									
	0	0	.00	1	3.57	0	.00	1	.89
	1	29	46.03	1	3.57	7	33.33	37	33.04
	2	18	28.57	11	39.29	9	42.86	38	33.93
	3	7	11.11	2	7.14	1	4.76	10	8.93
	4	1	1.59	2	7.14	1	4.76	4	3.57
	5	4	6.35	2	7.14	1	4.76	7	6.25
	6	3	4.76	2	7.14	0	.00	5	4.46
	7	1	1.59	7	25.00	2	9.52	10	8.93
3									
	0	1	1.59	1	3.57	0	.00	2	1.79
	1	43	68.25	12	42.86	15	71.43	70	62.50
	2	13	20.63	6	21.43	4	19.05	23	20.54
	3	5	7.94	5	17.86	0	.00	10	8.93
	4	1	1.59	1	3.57	1	4.76	3	2.68
	5	0	.00	2	7.14	0	.00	2	1.79
	6	0	.00	0	.00	0	.00	0	.00
	7	0	.00	1	3.57	1	4.76	2	1.79

TABLE 3 (con't)

Question number	Scale	English		Algebra		Basic		All	
		Type of Student							
4									
	0	1	1.59	0	.00	1	4.76	2	1.79
	1	5	7.94	5	17.86	1	4.76	11	9.82
	2	7	11.11	2	7.14	2	9.52	11	9.82
	3	13	20.63	1	3.57	3	14.29	17	15.18
	4	15	23.81	8	28.57	3	14.29	26	23.21
	5	7	11.11	5	17.86	2	9.52	14	12.50
	6	2	3.17	4	14.29	1	4.76	7	6.25
	7	13	20.63	3	10.71	8	38.10	24	21.43
5									
	0	0	.00	0	.00	0	.00	0	.00
	1	31	49.21	7	25.00	13	61.90	51	45.54
	2	14	22.22	3	10.71	3	14.29	20	17.86
	3	11	17.46	8	28.57	2	9.52	21	18.75
	4	4	6.35	2	7.14	2	9.52	8	7.14
	5	1	1.59	4	14.29	0	.00	5	4.46
	6	1	1.59	2	7.14	0	.00	3	2.68
	7	1	1.59	2	7.14	1	4.76	4	3.57
6									
	0	0	.00	1	3.57	0	.00	1	.89
	1	29	46.03	13	46.43	7	33.33	49	43.75
	2	13	20.63	6	21.43	3	14.29	22	19.64
	3	10	15.87	4	14.29	4	19.05	18	16.07
	4	1	1.59	1	3.57	1	4.76	3	2.68
	5	5	7.94	2	7.14	1	4.76	8	7.14
	6	2	3.17	0	.00	0	.00	2	1.79
	7	3	4.76	1	3.57	5	23.81	9	8.04

TABLE 3 (con't)

Question number	Scale	Type of Student: English		Algebra		Basic		All	
7									
	0	1	1.59	1	3.57	0	.00	2	1.79
	1	4	6.35	0	.00	0	.00	4	3.57
	2	10	15.87	0	.00	2	9.52	12	10.71
	3	18	28.57	6	21.43	3	14.29	27	24.11
	4	5	7.94	1	3.57	1	4.76	7	6.25
	5	17	26.98	5	17.86	4	19.05	26	23.21
	6	2	3.17	7	25.00	2	9.52	11	9.82
	7	6	9.52	8	28.57	9	42.86	23	20.54
8									
	0	0	.00	1	3.57	0	.00	1	.89
	1	37	58.73	12	42.86	14	66.67	63	56.25
	2	16	25.40	8	28.57	5	23.81	29	25.89
	3	6	9.52	1	3.57	1	4.76	8	7.14
	4	1	1.59	1	3.57	0	.00	2	1.79
	5	2	3.17	1	3.57	0	.00	3	2.68
	6	1	1.59	2	7.14	0	.00	3	2.68
	7	0	.00	2	7.14	1	4.76	3	2.68
9									
	0	0	.00	0	.00	0	.00	0	.00
	1	32	50.79	9	32.14	14	66.67	55	49.11
	2	18	28.57	8	28.57	3	14.29	29	25.89
	3	2	3.17	4	14.29	1	4.76	7	6.25
	4	6	9.52	2	7.14	2	9.52	10	8.93
	5	1	1.59	1	3.57	0	.00	2	1.79
	6	0	.00	1	3.57	0	.00	1	.89
	7	4	6.35	3	10.71	1	4.76	8	7.14

TABLE 3 (con't)

Question number	Scale	English		Algebra		Basic		All	
		Type of Student							
10									
	0	1	1.59	0	.00	0	.00	1	.89
	1	37	58.73	10	35.71	15	71.43	62	55.36
	2	10	15.87	7	25.00	1	4.76	18	16.07
	3	6	9.52	2	7.14	1	4.76	9	8.04
	4	4	6.35	4	14.29	2	9.52	10	8.93
	5	1	1.59	1	3.57	1	4.76	3	2.68
	6	1	1.59	1	3.57	0	.00	2	1.79
	7	3	4.76	3	10.71	1	4.76	7	6.25
11									
	0	0	.00	0	.00	0	.00	0	.00
	1	37	58.73	12	42.86	13	61.90	62	55.36
	2	13	20.63	5	17.86	5	23.81	23	20.54
	3	10	15.87	8	28.57	1	4.76	19	16.96
	4	3	4.76	2	7.14	0	.00	5	4.46
	5	0	.00	0	.00	0	.00	0	.00
	6	0	.00	1	3.57	1	4.76	2	1.79
	7	0	.00	0	.00	1	4.76	1	.89
12									
	0	2	3.17	0	.00	0	.00	2	1.79
	1	8	12.70	2	7.14	8	38.10	18	16.07
	2	8	12.70	4	14.29	4	19.05	16	14.29
	3	10	15.87	7	25.00	5	23.81	22	19.64
	4	11	17.46	2	7.14	1	4.76	14	12.50
	5	3	4.76	3	10.71	1	4.76	7	6.25
	6	2	3.17	4	14.29	0	.00	6	5.36
	7	19	30.16	6	21.43	2	9.52	27	24.11
13									
	0	0	.00	0	.00	0	.00	0	.00
	1	36	57.14	13	46.43	15	71.43	64	57.14
	2	12	19.05	5	17.86	5	23.81	22	19.64
	3	10	15.87	6	21.43	1	4.76	17	15.18
	4	3	4.76	3	10.71	0	.00	6	5.36
	5	0	.00	0	.00	0	.00	0	.00
	6	0	.00	1	3.57	0	.00	1	.89
	7	2	3.17	0	.00	0	.00	2	1.79

strongly agreed that they liked working at the teletypes, felt it was an exciting way to learn and wanted to participate in another CAI course. They also felt that CAI could best be used for drill and practice as a supplement to regular class work, and that such a course lasting for more than one quarter would be effective for college freshmen. Students liked the system because it allowed them to work at their own pace.

In the evaluation by Algebra students, no single item received 50 percent for a given number on the scale. However for items 1, 3, 6, 8, 9, 10, 11, and 13 the sum of the percentages for strongly agree and moderately agree exceeded 50 percent. These same items, with the exception of 1 and 6, were favored by English students. More than half of the Algebra students agreed that they worked as hard answering questions in the computer lessons as in the classroom and that sufficient time was provided for work in the Laboratory. More than 60 percent of the English students responded the same way to these two items. Students in BASIC Language evaluated favorably (with higher percentages) the same items as did other students. In addition, 62 percent of them felt that the computer served as a personal tutor. However, more than half of these students disagreed to some extent that they had sufficient time to work in the Laboratory. It might also be of interest that 72 percent of the Algebra students and BASIC Language students did not feel that the lessons were too easy, and only 40 percent of the students felt this way about the English lessons. English and BASIC Language students, 74 percent and 76 percent, respectively, strongly or moderately agreed that they learned from the computer lessons as well as they would have learned the same lesson in the classroom. Only 42 percent of the Algebra students gave the same response.

The teacher evaluation consisted of a total of 29 items in three parts. The data are presented in Table 4.

Insert Table 4 here

Results that may be interesting to note are the following: in the first part all of the teachers strongly or moderately agreed that students learn facts and review facts faster in a CAI environment than in the classroom. Four out of five of them agreed, moderately or strongly, that CAI allows students to work as individuals at their own pace and according to their ability. Four of the five teachers moderately agreed that CAI approximates the interaction of a patient tutor. All of the teachers moderately agreed that CAI absorbs the attention and encourages the total involvement of students and that it is a good or plausible approach to individualized instruction. The results also indicate that teachers do not feel threatened that computers will replace them. Four of the five strongly or moderately agreed that lesson materials should be edited and modified by teachers at the university involved in the program. The second and third parts of the evaluation indicated that

TABLE 4

Responses to Teacher Questionnaire

Number of teachers responding

Part I Item Number	Scale 0	1	2	3	4	5	6	7
1		3	2					
2		2	2	1				
3				3		1	1	
4				2	2		1	
5		1				2	2	
6		1			1	1	2	
7						1	4	
8		1	1		2			1
9		2	1	1	1			
10		1		2			1	1
11			2	2				1
12		1	4					
13	1		1		2		1	
14				2			2	1
15		1	2	1		1		
16		2	2	1				
17		3	1	1				

TABLE 4 (con't)

Part II Item Number				Number of teachers responding Scale				
	0	1	2	3	4	5	6	7
1. a		3	2					
b		3	2					
c			1	2	1	1		
d		1	4					
e					3	1	1	
f			1	2	2			
g			4		1			
2. a		1	2	1		1		
b			1	2	2			
c		1		2	2			
d			4		1			
e		1	4					

teachers see computer-controlled learning as being effective, valuable, useful and motivative, and that students who learn on computers are relaxed and interested.

It was felt that the evaluation forms, as designed, would not be suitable for use in the Summer Quarter due to the diversified groups using the laboratory, and consequently, data for that period are not reported.

SOME PROBLEMS

The Spring Quarter was underway before the CAI Laboratory was available for use, which meant that students did not spend as much time in the Laboratory as they would during a full quarter. There was also the problem of informing the faculty that the program was in progress. A letter was sent to each faculty member with information about the program and an invitation to visit the Laboratory. In addition, calls were made to those staff members, who, it was felt, might be interested in the Spanish Drill, GED Progams and the Adult Reading Program. The GED Program, a CAI program to train adults for the High School Equivalency Examination, was available at TSU, but was not used. An effort was made by the administration to enroll interested persons in the community in the GED and Adult Reading courses, but because so little time was available this was not successful.

In most of the English classes the instructor was in the Laboratory with the students. If a student had a question, the instructor was there to help. In one large class that had two laboratory periods it was, of course, impossible for the instructor to attend both periods. In Algebra and BASIC Computer Language the Director of the Laboratory was available to answer students' questions.

In the Algebra class, unfortunately, the instructor became ill halfway through the quarter, and attendence problems developed after the instructor's illness. Further, the Algebra class was divided into two laboratory periods. Students did not bring previous lessons with them to the Laboratory and, as a result, were often lost in the new lesson. Responses on the evaluation by Algebra students probably reflect some of these problems.

During the Spring Quarter problems arose with telephone lines, but the company had this cleared by the beginning of the Summer. However, at that time Stanford was working on the computer system, which caused further problems, especially in the afternoons. Fortunately, most of the laboratory periods were scheduled in the mornings.

The Coordinator of CAI taught two classes during the Spring Quarter and one during the Summer Quarter. There was one laboratory period in each quarter scheduled at one of these hours, and students were sometimes inconvenienced and occasionally lost class time as a result of the Coordinator's absence from the Laboratory.

APPENDIX 1

Hardware Configuration Servicing CAI Laboratory at Tennessee State University

Terminals: 25 Model-33 KSR Teletypes, 20 operational, 5 spares.

Multiplexing equipment: PDP-8 table model computer with an auxilliary cabinet that contained:

1. A 680 data communication which accommodated 20 channels.

2. An RS-232 interface panel which accommodated 20 terminals and had capacity for 24. This provided EIA level conversion for 20 teletypes.

3. A DP01-A, an interface that allowed the processor to talk to a single telephone line in a synchronous manner in both directions, usually at 2400 baud. The interface was connected to a 201-type data set.

4. An autoloader, which enabled IMSSS to operate the switch register of the PDP-8 over the phone line through the DP01-A, thereby allowing remote reloading and restarting of the PDP-8.

The TSU system communicated with the PDP-10 through a highspeed communications line receiver-transmitter at the IMSSS Laboratory.

APPENDIX 2

Description of Algebra Course

The Algebra course is divided into three parts. In the first part, the student is provided instruction in fundamental computational skills, in the second he solves arithmetic word problems and in the third he constructs proofs and counter-examples about algebraic expressions. The student studies properties of numbers and operations on these numbers.

Part 1. Basic Arithmetic Skills

The program is designed to diagnose the weaknesses and strengths in the arithmetic background of a student and to provide an instructional program adapted to his level of achievement. The topics included are designed to increase the student's skill in adding, subtracting, multiplying and dividing integers, fractions, decimals and measures, and his ability to manipulate simple algebraic expressions.

The curriculum covers eight topics: addition (ADD), subtraction (SUB), multiplication (MUL), division (DIV), equations (EQN), fractions (FRA), measurement (MEA) and decimals (DEC). The problems in each topic constitute a strand. Each strand is divided into classes of problems that are ordered according to difficulty level and according to a careful instructional rationale. The entire curriculum is organized into a structure with 36 levels. The levels spanned by each strand are shown in Figure 1.

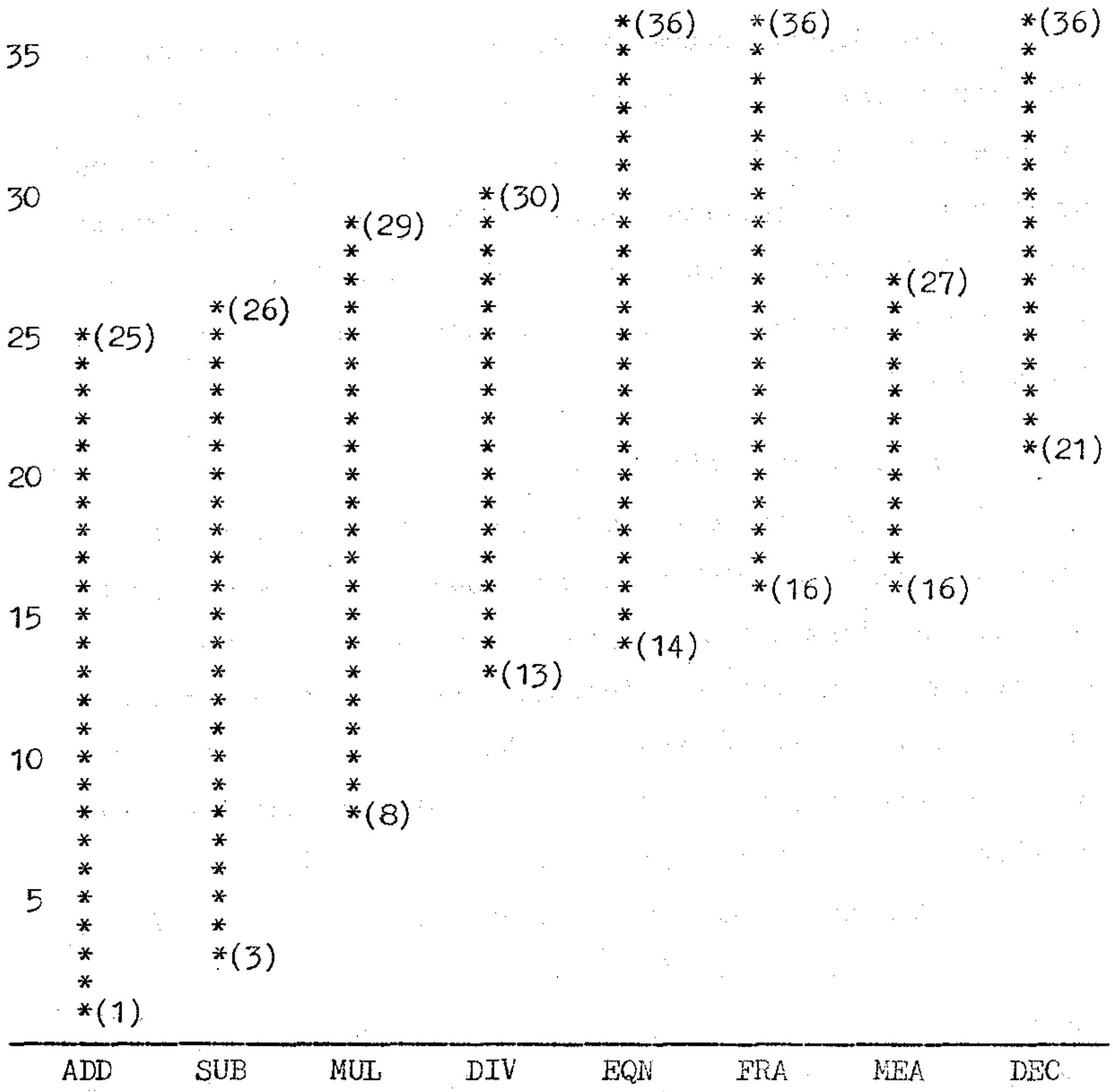

Figure 1. Algebra Course, Part 2. Curriculum levels defined for each strand.

Placement in each strand can be independent of placement on all others. Movement on a single strand depends only on performance on that strand; when the student responds correctly to enough problems in a class to meet the criterion for that class he is moved to the next class in the strand. If a student fails to meet a minimal performance criterion in a class he is branched to one that provides practice in the necessary prerequisite skills.

All of the problems in the curriculum are generated by the computer, according to the specifications defined for the level and class. As a student at a terminal works a problem his responses are evaluated by the computer program, character by character. As soon as an incorrect character is typed, the program prints an error message, retypes the problem to the point where the error was made, and allows the student another chance to type the character which he previously typed incorrectly. If a second error is made, the program gives the student the correct answer and allows him to type it in. Then the program moves to the next problem.

Part 2. Arithmetic Word Problem Solving

The problem-solving course presents arithmetic word problems to a student. The student solves problems by forming algebraic expressions and having the computer carry out the actual computations. The most important learning experience in arithmetic word problems is translating the English text into an algebraic expression. When such problems are presented in textbooks the student is often bogged down in the actual computation and the correctness of his solution may be masked by careless errors in arithmetic. Having the computer do the actual computations lets the student concentrate on the more difficult aspect of finding the solution.

The student learns a set of simple commands that he uses to tell the computer which computations to carry out. Most of the commands are given in the form of algebraic expressions. The student is free to experiment with the computer calculator made available to him. His answer is evaluated by the computer only when he decides that he knows the correct answer.

To aid the student when he requests help, the instructional program provides general information on how to solve the problem as well as hints about specific features of the problem. The problem-solving curriculum consists of about 700 word problems of varying difficulty organized into a single linear strand. The problems have been carefully analyzed and are arranged roughly in order of increasing difficulty.

The curriculum starts with a set of instructional problems that illustrate methods of solution and provide practice in using the commands the student is taught.

Part 3. The Properties of Numbers

The main thrust of this part of the course is to teach the student skills in constructing mathematically valid proofs. The student is taught a command language with which he can construct proofs and find counterexamples about number sentences. The program acts as a proof-checker, providing error messages if a command is invalidly used and hints when the student requests help on a problem. The student learns rules for manipulating equations as well as axioms of an additive and multiplicative group. The student can use theorems about addition and multiplication in subsequent problems after he has proved them. Other modes of operation include: (a) assigning values to variables to make an open sentence true or false, (b) computing the truth value of a sentence given numerical values for the variables, and (c) applying the proof procedures to finding simplifications to complex algebraic expressions.

There are 27 lessons in the curriculum. The outline given on the next page provides a summary of the topics covered. This outline is followed by a list of the rules, axioms and theorems.

Algebra Course, Part 3

Outline of Lessons

Lesson Number	Topic
301	review of teletype operations
302	introduction to number sentences
303	truth value of sentences assign values to the variables to make an open sentence true or false
304	equations finding solutions to equations
305	truth value of equations for given values of the variables introduction to finding counterexamples
306	introduction to constructing proofs nd – number definition rule ce – commute equals rule
307	ae – add equals rule
310	rq – replace equals rule (long form)
311	constructing counterexamples (most problems from here on are of the form: derive or find a counterexample)
312	se – subtract equals rule
313	re – replace equals rule (short form)
314	more about replace equals and counterexamples
315	ca commute addition axiom (a+b)=(b+a) short form of ca
316	as associate addition axiom (a+b)+c=a+(b+c) ar associate addition right al associate addition left

Outline of Lessons (continued)

317	z zero axiom a+0=a
320	n negative number axiom a+(-b)=a-b
321	ai additive inverse axiom a+(-a)=0
322	use of theorems in proofs theorems 1-6 redundancy of ae, se, ca, ar, al
323	relation of subtraction to addition
324	theorems 7-11
325	theorems 12-16
326	cm commute multiplication axiom axb=bxa mu multiplication by unity axiom ax1=a theorem 17
327	me multiply equals rule
330	mi multiplicative inverse ax(1/a)=1 , for a=0 false
331	ms associate multiplication (axb)xc=ax(bxc) mr associate multiplication right ml associate multiplication left
332	dl distributive axiom ax(b+c)=(axb)+(axc) theorem 18-23
333	applications of the rules to finding simplifications of algebraic expressions

List of Theorems

Axioms

CA	$a+b=b+a$
AS	$(a+b)+c=a+(b+c)$
Z	$a+0=a$
AI	$a+(-a)=0$
N	$a+(-b)=a-b$
CM	$a x b=b x a$
MU	$a x 1=a$
MS	$(a x b)+x c=a x(b x c)$
DL	$a x(b+c)=(a x b)+(a x c)$

Theorems

1	$0+a=a$
2	$(-a)+a=0$
3	$a-a=0$
4	$0-a=-a$
5	$0=-0$
6	$a-0=a$
7	$-(-a)=a$
8	$(-(a+b))+b=-a$
9	$-(a+b)=(-a)-b$
10	$(-a)-b=(-b)-a$
11	$-(a-b)=b-a$
12	$(a-b)-c=a+((-b)-c)$
13	$(a-b)-c=a-(b+c)$
14	$a+(b-a)=b$
15	$a-(b+a)=-b$
16	$(a-b)+(b-c)=a-c$
17	$1 x a=a$
18	$(b+c) x a=(b x a)+(c x a)$
19	$0 x a=a$
20	$a x(-b)=-(a x b)$
21	$(-a) x(-b)=a x b$
22	$a x(b-c)=(a x b)-(a x c)$
23	$(b-c) x a=(b x a)-(c x a)$

Rules

AE	add equals
SE	subtract equals
ME	multiply equals
ND	number definition
CE	commute equals
RE	replace equals

APPENDIX 3

TENNESSEE STATE UNIVERSITY
COMPUTER-ASSISTED INSTRUCTION PROGRAM
SPRING QUARTER 1972

STUDENT EVALUATION FORM

Please read each statement and circle the number on the scale that best describes your feelings.

SCALE:

1 Strongly agree
2 Moderately agree
3 Slightly agree
4 Uncertain
5 Slightly disagree
6 Moderately disagree
7 Disagree

1. I worked as hard answering questions in the computer lessons as I did in the classroom.

   1 2 3 4 5 6 7

2. I learned from the computer lessons as well as I would have learned the same lesson in the classroom.

   1 2 3 4 5 6 7

3. I like working at my own pace at the teletype.

   1 2 3 4 5 6 7

4. I would prefer competing with my fellow students in the classroom rather than working at computer lessons.

   1 2 3 4 5 6 7

5. Working with computer lessons is like having my own tutor.

   1 2 3 4 5 6 7

6. I was provided with sufficient time to work in the lab.

   1 2 3 4 5 6 7

7. I found the computer lessons too easy.

   1 2 3 4 5 6 7

STUDENT EVALUATION FORM (con't)

8. I think working with computer lessons is an exciting way to learn.

   1 2 3 4 5 6 7

9. I would like to participate in another CAI course.

   1 2 3 4 5 6 7

10. I think a CAI course which would last for more than one quarter would be effective for college freshmen.

    1 2 3 4 5 6 7

11. CAI can best be used for drill and practice sessions which supplement the regular teaching process.

    1 2 3 4 5 6 7

12. The CAI system used this quarter permits the student to ask questions of the computer which he otherwise would not ask.

    1 2 3 4 5 6 7

13. UNDERLINE THE CAI COURSE YOU WERE ENROLLED IN:

    1. Basic English 2. Algebra 3. Basic Computer Language

14. Make any comment you wish concerning the CAI program:

TENNESSEE STATE UNIVERSITY
COMPUTER-ASSISTED INSTRUCTION PROGRAM
SPRING QUARTER 1972

TEACHER EVALUATION FORM

Please read each statement and circle the number on the scale that best describes your feelings.

SCALE:

1 Strongly agree
2 Moderately agree
3 Slightly agree
4 Uncertain
5 Slightly disagree
6 Moderately agree
7 Strongly disagree

1. Students learn facts and/or review facts faster in CAI lessons than in groups in the classroom.

   1 2 3 4 5 6 7

2. With CAI students work as individuals at their own pace, and according to their own ability.

   1 2 3 4 5 6 7

3. Students feel uncertain because they do not know how they compare with others in class.

   1 2 3 4 5 6 7

4. Students just try to get through materials rather than learn.

   1 2 3 4 5 6 7

5. Since no one watches them, students do not care if they make errors.

   1 2 3 4 5 6 7

6. CAI tends to disrupt my classroom procedures.

   1 2 3 4 5 6 7

7. I feel threatened that computers might replace teachers.

   1 2 3 4 5 6 7

8. Students in CAI courses have shown more interest in their class work than those students in the same courses not enrolled in CAI.

   1 2 3 4 5 6 7

9. I think a CAI course which would last the school year would be more effective for college freshmen.

   1 2 3 4 5 6 7

10. CAI can best be used for drill and practice sessions which supplement the regular teaching process.

    1 2 3 4 5 6 7

11. The main responsibility of CAI is that of helping the student understand a concept and develop skill in using it.

    1 2 3 4 5 6 7

12. CAI approximates the interaction of a patient tutor.

    1 2 3 4 5 6 7

13. I feel that CAI can permit the student to conduct a genuine two-way conversation.

    1 2 3 4 5 6 7

14. The CAI system used this quarter permitted students to ask questions of the computer which they otherwise would not ask.

    1 2 3 4 5 6 7

15. The interactive nature (two-way conversation) of CAI as an instructional medium typically absorbs the attention and encourages the total involvement of students.

    1 2 3 4 5 6 7

16. I believe the lesson materials should be edited and modified by teachers at our institution.

    1 2 3 4 5 6 7

17. I believe CAI is a good or plausible approach to improved individualization in a wide array of course or subject-material areas.

    1 2 3 4 5 6 7

TEACHER EVALUATION FORM (con't)

Please circle the number on the scale that best describes your feelings about the statements below.

SCALE:

1 Very good
2 Moderately good
3 Slightly good
4 Uncertain
5 Slightly bad
6 Moderately bad
7 Completely bad

1. Computer controlled learning is:

EFFECTIVE	1	2	3	4	5	6	7	INEFFECTIVE
VALUABLE	1	2	3	4	5	6	7	WORTHLESS
FLEXIBLE	1	2	3	4	5	6	7	INFLEXIBLE
USEFUL	1	2	3	4	5	6	7	USELESS
HARD	1	2	3	4	5	6	7	EASY
EFFICIENT	1	2	3	4	5	6	7	INEFFICIENT
MOTIVATIVE	1	2	3	4	5	6	7	NON-MOTIVATIVE

TEACHER EVALUATION FORM (con't)

2. Students who learn on computers are:

ACTIVE	___ 1	___ 2	___ 3	___ 4	___ 5	___ 6	___ 7	PASSIVE
RELAXED	___ 1	___ 2	___ 3	___ 4	___ 5	___ 6	___ 7	TENSE
BUSY	___ 1	___ 2	___ 3	___ 4	___ 5	___ 6	___ 7	LAZY
CALM	___ 1	___ 2	___ 3	___ 4	___ 5	___ 6	___ 7	FRUSTRATED
INTERESTED	___ 1	___ 2	___ 3	___ 4	___ 5	___ 6	___ 7	BORED