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Identifiers-AID, Algebraic Interpretive Dialogue

Described in this report is the strand program as used in the teaching of drill-and-practice mathematics in California, Kentucky, and Mississippi schools, at the Tennessee A. and I. University, and in Washington, D.C.; as used in the drill-and-practice reading courses; in logic and algebra; in a second-year Russian program, and in computer-assisted instruction in programing in the AID and the SIMPER and LOGO projects. In mathematics, the strand program breaks the subject area down to 14 heads (counting, vertical addition, horizontal addition, etc.) and tackles them one at a time. The reading program is linear, and consists of five parallel strands: letter identification, sight-word recognition, phonics, spelling patterns, and word meaning. The report describes the first year logic and algebra program, and tabulates a course outline for the second year. The second year Russian is reported (the course was first offered in 1967-8 at Stanford) and, in this, 74% of the computer-based students performed better than the best student in the conventional class. Activities planned for the next reporting period are detailed, and a list of publications and lectures is appended. (GO)

PROGRESS REPORT

STANFORD PROGRAM IN COMPUTER-ASSISTED INSTRUCTION

for the period

OCTOBER 1, 1968 to DECEMBER 31, 1968

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INSTITUTE FOR MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES
STANFORD UNIVERSITY
STANFORD, CALIFORNIA

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I. Major Activities of the Reporting Period

A. Drill-and-practice Mathematics Program

1. Strand Program

The first 14 strands in the strand program were evaluated by staff members, and several other individuals with elementary level classroom experience, both for appropriateness of grade placement assignments and for selection of problem types. The curriculum group used these evaluations for the final revision of the strands.

The 14 strands include a total of 725 equivalence classes, distributed as shown in Table 1. The starting point for each strand was chosen to correspond with the introduction of the topic in three elementary mathematics text series.[1] Four strands start at grade level 1.0. First graders, however, probably will not begin work at teletypes during the first months of the school year. Rather, we expect that teachers will wait until students have learned to work the problems presented in the first equivalence classes before beginning the teletype program.

Five strands terminate before the end of the sixth grade. Although it would be possible to prolong the addition and subtraction strands indefinitely by increasing the size of the numbers presented, the curriculum group felt that there is no justification for requiring long computations involving large numbers. The largest problems at the end of the vertical addition strand require finding the sum of four three-digit or three four-digit numbers. The problems in the last classes in the vertical subtraction strand involve five-digit numbers, with several regroupings and regrouping across zeros.

The teletype response format for problems in vertical format permits the entry of partial answers (e.g., individual column sums or differences). This is not true for problems presented in horizontal format. For these, the answer is

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[1] Eicholz, R. E., & O'Daffer, P. G. Elementary school mathematics, Grades 1-6. Palo Alto, California: Addison-Wesley, 1968.

Payne, J. W. et al. Elementary mathematics, Grades 1-6. New York: Harcourt, Brace & World, 1966.

Suppes, P. Sets and numbers, Grades 1-6. New York: Singer, 1966.

TABLE 1

Distribution of Equivalence Classes over Grades and Strands

Strand no.	Name	Half-grade Level												Totals
		1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	
1	Counting	10	10	10	5	5	5	5	5	5	5	10	5	80
2	Vertical Addition	5	5	5	10	10	5	10	5	5	5			65
3	Horizontal Addition	10	10	10	5	5								40
4	Vertical Subtraction		5	5	10	10	5	10	5	5	5			60
5	Horizontal Subtraction	5	5	5	5	5								25
6	Equations		5	10	10	10	5	10	5	5	5	5	5	75
7	Horizontal Multiplication				5	5	10	10	5	5				40
8	Vertical Multiplication						10	5	10	5	5	5	5	45
9	Fractions						5	5	10	10	10	10	10	60
10	Division						5	5	10	10	5	5	5	45
11	Measurement Large Numbers		5	5	10	10	10	10	10	10	10	10	5	95
12	Decimals					5	5	5	5	5	5	5	10	45
13	CAD Laws					5	5	5	5	5	5	5	5	40
14	Negative Numbers											5	5	10
	Totals	30	45	50	60	70	70	80	75	70	60	60	55	725

entered from left to right. Partial answers must be held in memory before the full answer can be entered. This fact severely limits the magnitude of the answer for problems presented in horizontal format. Hence, the strands covering basic arithmetic problems presented in horizontal format terminate early in comparison with those containing similar problems presented in vertical format.

Extension to seventh and eighth grade. The strand program is currently being extended to the junior high school level. Two strands, vertical multiplication and division, will terminate at the end of the sixth grade. The remaining seven strands will continue with material for seventh and eighth grades. During the quarter a count was made of problem types appearing in three junior high school mathematics text series.[2] Using the strand definitions developed for grades 1 to 6, approximately 20,000 problems from the junior high school texts were classified by strands. Frequency of occurrence of problem types was tabulated by strand for each half grade for these problems, which comprise approximately two-thirds of the total number of text problems. The proportions are given in Table 2.

An examination of the organization of the junior high school texts suggests that there is less agreement about grade placement for topics in the junior high school curriculum than for topics in the elementary grades. As a result, we expect to make many difficult and arbitrary decisions about the ordering of equivalence classes in these strands extending through grades 7 and 8.

Geometry strand. Work was started on a tutorial geometry strand that incorporates concrete materials and a workbook, as well as interaction with the teletype. The curriculum is expected to be more extensive than that found

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[2] Dolciani, M. et al. Modern school mathematics, Grades 7 and 8. Boston: Houghton Mifflin, 1967.

Keedy, M. et al. Exploring modern mathematics, Book 1 and 2. New York: Holt, Rinehart & Winston, 1968.

Suppes, P. et al. Sets, numbers and systems, Book 1 and 2. New York: Singer, 1969.

TABLE 2

Proportion of Problems from Seventh- and Eighth-grade Texts Appropriate to Each Strand

Strand number	Strand name	Half-grade Level 7.0-7.4	7.5-7.9	8.0-8.4	8.5-8.9
1	Counting	.42	.13	.29	.14
2 and 3	Addition	.01	.00	.00	.00
4 and 5	Subtraction	.01	.01	.00	.00
6	Equations	.11	.04	.09	.50
7 and 8	Multiplication	.01	.01	.00	.00
9	Fractions	.03	.21	.03	.04
10	Division	.02	.01	.00	.00
11	Measurement and large numbers	.04	.14	.07	.04
12	Decimals	.05	.31	.10	.14
13	CAD Laws	.20	.07	.21	.06
14	Negative numbers	.10	.06	.21	.08

in any of the standard elementary level text series. As a prelude to initial organization and writing, several text series and supplementary workbooks were surveyed.[3] The results of the survey were used to develop a list of 12 topics suitable for an informal treatment of geometry at the elementary level. The list of topics, with some explanatory phrases, is given in Table 3. A list of shapes suggested for inclusion in the curriculum is also given in the table.

Basic decisions about the organization of the geometry strand, grade placement and an appropriate mixing of different topics remain to be made.

2. Use of the System in Schools

The number of tests and lessons taken on the system in each area during this reporting period totalled 83,007 as shown in Table 4. The California column does not include the number of tests and lessons given in the Ravenswood School District. These figures are given in a separate column.

Figure 1 presents a diagram of the Stanford instructional system showing the number of teletype terminals at each location. Although there are 64 local lines, not all of them are currently in use.

3. California Schools

The number of students given lessons each day is shown in Table 5. 'Lab' indicates demonstration lessons taken from various places that use demonstration numbers. 'Special Accounts' are those users who dial in for lessons under

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[3]Abbott, Janet S. Learn to fold-fold to learn, mirror magic, The Franklin mathematics series. Pasadena, California: Franklin Publications, 1968.

Eicholz, R. E., & O'Daffer, P. Experiences with geometry. Palo Alto, California: Addison-Wesley, 1966.

Friend, J., & Suppes, P. Symmetry. Stanford, California: Institute for Mathematical Studies in the Social Sciences, 1965.

Phillips, J. M., & Zwoyer, R. E. Motion geometry. Evanston, Illinois: Harper & Row, 1969.

Roper, S. Paper and pencil geometry, The Franklin mathematics series. Pasadena, California: Franklin Publications, 1968.

School Mathematics Study Group. Mathematics for the elementary school, Books 1-6. New Haven, Connecticut: Yale University Press, 1965.

Suppes, P. Sets and numbers, Grades 1-6. New York: Singer, 1966.

Wirtz, R. W. et al. Math workshop. Chicago, Illinois: Encyclopedia Britannica Press, 1964.

TABLE 3

Topics to be Included in the Geometry Strand

1. Conservation:	Invariance of size and shape under rigid motion.
2. Recognition of figures:	Names (triangle, rectangle, etc.), properties (sides, vertices, diagonals, faces, etc.).
3. Use of letters for specifying points and lines:	Line segments, rays, angles, plane figures, points of intersection, vertices.
4. Congruence:	Recognition by matching, visual recognition, properties of figures which remain invariant.
5. Similarity:	Visual recognition, scale drawings, maps.
6. Relationships between one-, two-, and three-dimensional figures:	Identification of plane figures as faces of solids, building of plane figures using line segments, shapes of intersections of planes with solid figures.
7. "Nonmetric" measurement:	Use of unit lengths, unit areas, comparative areas of similar figures, relationships between changes in linear dimensions and change in area and volume.
8. Symmetry:	About a line, about a point.
9. Topological ideas:	Points inside, outside, on a curve, line segments which stay inside, go outside regions, closed, open curves.
10. Motions:	Rotations, translations, reflections, invariance of single figures, patterns.
11. Perspective:	Association of drawings with three-dimensional objects, recognition of different views of the same object.
12. Coordinates (?)	

Figures to be included: Triangle (equilateral, isosceles, scalene), quadrilateral, pentagon, circle, rectangle, square, polygon (six and more sides), parallelogram, rhombus, trapezoid, rectangular prism, triangular prism, rectangular pyramid, triangular pyramid, cylinder, cone, sphere.

TABLE 4

Total Number of Tests and Lessons Given Students in Each Area

	California	Kentucky	Mississippi	Ravenswood	Washington, D.C.	Logic	
October							
9	136	46	18	1		32	
10	148	123	--	35		32	
14	96	--	--	3		26	
15	207	--	--	5		38	
16	191	--	47	11		18	
17	240	--	132	41		18	
18	223	--	285	40		31	
21	121	27	378	41		--	
22	238	52	470	34		21	
23	179	87	427	41		3	
24	224	57	721	59		26	
25	275	98	838	32		29	
28	291	31	652	40		22	
	2,569	521	3,968	383		296	7,737
29	371	65	--	49		29	
30	407	51	831	33		39	
31	282	94	1,460	32		30	
November							
1	309	56	1,360	32		29	
4	416	5	1,823	25		37	
5	389	9	2,046	34		35	
6	420	8	1,645	35		26	
7	364	205	2,012	33		36	
8	423	183	1,883	57		18	
11	69	36	1,975	--		9	
12	451	--	2,055	77		34	
13	534	4	1,681	82		7	
14	334	78	2,128	109	128	5	
15	307	14	2,027	90	100	18	
18	327	288	1,980	99	130	4	
19	267	314	1,672	107	139	17	
20	386	245	1,990	120	113	5	
21	329	278	1,471	111	122	24	
22	249	309	1,895	94	100	10	
25	352	293	1,903	104	102	4	
26	274	345	1,624	102	80	--	
27	354	241	1,677	112	96	8	
December							
2	404	--	1,044	134	55	--	
3	272	--	616	115	34	--	
4	28	16	375	7	8	--	
5	285	177	1,659	156	115	--	
6	189	145	1,073	34	33	16	
9	393	275	1,742	90	83	--	
10	309	334	1,746	85	96	--	
11	335	626	1,208	77	75	--	
12	296	160	1,614	105	95	3	
13	208	144	1,704	192	18	--	
16			SYSTEM	DOWN			
17							
18	211	222	1,462	211	98	--	
19	260	241	1,502	133	48	--	
20	199	137	548	--	54	--	
TOTALS	13,572	6,124	57,399	3,259	1,922	731	
							83,007

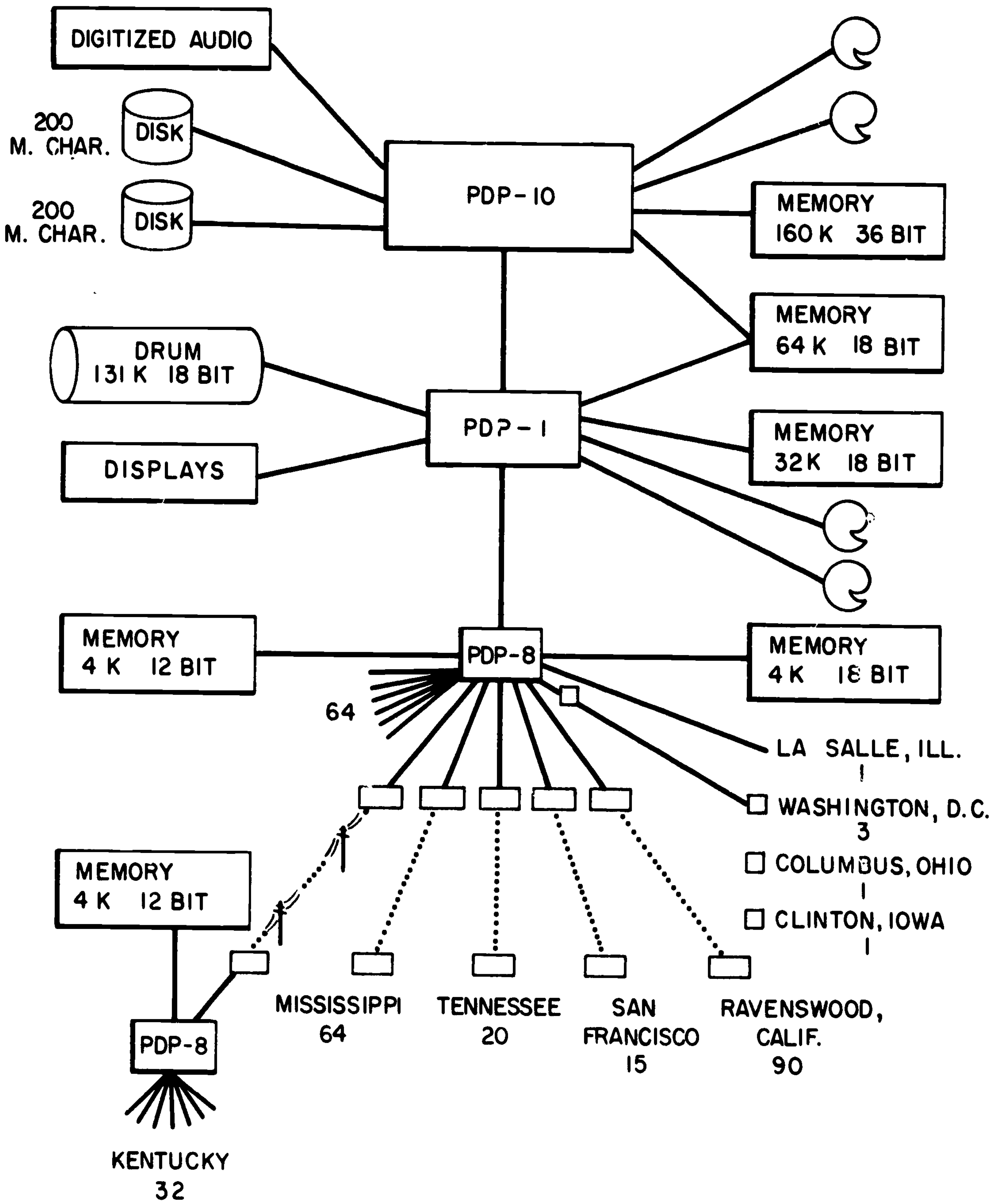

Fig. 1. The Stanford CAI System Configuration

TABLE 5

Number of Students Given Lessons at Each School in California

(Including Logic Students)

Drill-and-practice Mathematics

California schools	October 8	9	10	11	14	15	16	17	18	21	22	23	24	25	28	29	30	31
Lab	16		13	16	3	8		12	10		10	16	21	9	11	6	9	13
Special accounts								--	5		6	3	8	4	8	2	2	1
Walter Hays	10		15	14	6	21		24	20		19	--	48	64	96	156	158	123
Jordan Junior High								15	--		--	15	--	--	18	1	15	1
Fremont Hills	6		19	18	16	27		26	29		26	29	26	29	29	30	30	28
Oak Knoll	57		59	80	42	102		93	92		90	89	92	95	102	93	92	84
Belle Haven*																		
Brentwood*								26	26		26	--	26	25	25	25	26	22
Costano*																		
James Flood*																		
Kavanaugh*																		
O'Connor*																		
Runnymede*																		
Willow*																		
Peter Burnett Junior High						43		59	56		51	53	57	62	35	36	36	47
Totals	89		106	128	67	201		255	238		228	205	278	288	325	349	369	319

*Ravenswood schools

Table 5 (con't.)

Number of Students Given Lessons at Each School in California

(Including Logic Students)

Drill-and-practice Mathematics

California schools	November 1	4	5	6	7	8	11	12	13	14	15	18	19	20	21	22	25	26	27
Lab	8	9	17	12	11	25	--	22	15	24	15	8	22	26	12	16	13	7	7
Special accounts	--	1	--	6	5	3	--	6	8	5	3	4	6	11	5	7	1	1	1
Walter Hays	129	155	158	153	158	151	--	162	144	114	118	113	60	119	97	91	146	113	19
Jordan Junior High	--	19	1	16	--	1	--	1	16	1	1	20	--	16	--	1	17	--	--
Fremont Hills	24	24	26	29	27	24	--	29	30	23	--	8	20	22	25	13	27	20	--
Oak Knoll	84	91	94	92	92	93	--	93	94	94	89	84	91	93	92	88	95	72	--
Belle Haven							--												
Brentwood	52	48	50	24	50	72	--	68	65	69	64	75	73	82	93	81	93	102	--
Costano																			
James Flood																			
Kavanaugh																			
O'Connor																			
Runnymede																			
Willow																			
Peter Burnett Junior High	46	59	53	56	58	62	--	54	54	55	58	52	55	3	50	36	55	45	--
Totals	343	406	399	388	401	431		435	426	385	347	364	327	372	374	333	447	360	27

Table 5 (con't.)

Number of Students Given Lessons at Each School in California

(Including Logic Students)

Drill-and-practice Mathematics

California schools	December 2	3	4	5	6	9	10	11	12	13	16	17	18	19	20
Lab	5	4	4	3	4	9	17	11	11	20			5	7	9
Special accounts	5	1	7	1	2	2	3	--	2	--			--	--	--
Walter Hays	148	106	21	97	63	127	164	147	120	48			25	74	89
Jordan Junior High	15	1	--	--	--	17	17	15	--	--			--	--	--
Fremont Hills	29	16	--	24	19	30	32	30	23	2			31	28	20
Oak Knoll	89	73	9	92	69	85	125	84	73	79			41	36	1
Belle Haven								--	1	1			--	--	--
Brentwood	126	117	12	119	26	--	--	122	119	153			165	118	--
Costano								1	1	--			--	--	--
James Flood										--			--	--	--
Kavanaugh													--	--	--
O'Connor													--	--	--
Runnymede													--	--	--
Willow													--	--	--
Peter Burnett Junior High	39	39	12	48	13	51	60	4	52	52			51	40	36
Total	456	357	65	384	196	321	418	414	402	355			318	303	155

special arrangements. In many cases these are for demonstrations at various conferences or small numbers of users at remote locations.

The eight Ravenswood City School District schools are included in Table 4. Of the 90 teletype terminals to be used in their project, 50 will be used for mathematics only and 40 will be used for reading only. Students from grades 1 through 6 were given lessons as shown in Table 4. Several of the schools were not able to begin operation because of the late delivery of equipment and delay in installing telephone lines. Temporary buildings were constructed at each school to house the teletype terminals and to provide extra classroom space for the schools. Some of the buildings were not completed in time to permit installation of telephone lines and teletypes during this reporting period.

4. Kentucky Schools

The number of students given lessons and tests in Kentucky schools is shown in Table 6. The 32 teletype terminals were to be located in 30 different schools for demonstration and research purposes. Due to a delay in telephone-line installation, only 10 of the schools were able to run on a daily basis during this reporting period.

The dash lines shown in this table indicate that student name lists were submitted to the schools, but no students took lessons.

The distribution of students at each grade level in 24 of these schools whose name lists were received is shown in Table 7.

5. Mississippi Schools

Students were given 57,399 tests and lessons on 60 teletype terminals during this reporting period as shown in Table 4. Table 8 presents the number of students who received lessons each day of the quarter at each school. The average number of students taking lessons each day at each terminal was approximately 30. The largest number of students taking lessons on a single day, December 10, was 1,943. For that day, the average number of students run per terminal was 32.

This year students from grades 2 through 9 are involved in the program. First graders were dropped from the program since they were unable to make use of the terminals until nearly mid-year because of reading difficulties and immaturity. It was decided to move into the junior high school area rather than to let the terminals sit idle for part of the year. The junior high school program seems to be a success. Mississippi has no kindergarten program.

6. Tennessee A. and I. University

Students in limited numbers ran on demonstration lessons during the quarter. Because of the delay in completing the temporary classroom constructed as the CAI laboratory, the system became operational only late in their quarter. It was decided therefore to postpone the operation until the start of the quarter after the first of the year.

Work continued at Stanford on lesson preparation and editing. Descriptions of the lessons were included in detail in the previous quarterly report.

7. Washington, D.C.

Early in November, three terminals were installed in Kendall School for the Deaf which is on the campus of Gallaudet College in Washington, D.C. A one-day workshop and demonstration was held for the staff on November 7, and students began taking daily lessons on November 14. The number of lessons given each day to students in grades 1 through 6 is shown in Table 4. To date the children have done well and are highly motivated.

The three terminals at Kendall School are connected by a single telephone line to the computer at Stanford. Signals for the three terminals are multiplexed over a single, long-distance line by Collins Radio equipment.

TABLE 6

Number of Students Given Lessons at Each School in Kentucky

(Including Logic Students)

Drill-and-practice Mathematics

Kentucky schools	October 8	9	10	11	14	15	16	17	18	21	22	23	24	25	28	29	30	31
Breckinridge	28		82	9							28	46	38	62	14	47	30	54
Elliottville	33		24	13							21	6	--	--	--	--		20
Paintsville			--	--											3	--		
Upper Tygart			--	--														2
Sandy Hook			--	--														
Pikeville			--	--														
Louisa			--	--							6	20	3	19	11	3	8	--
Flat Gap			--	--														
Holy Family			--	--														
Pine Acres																		
Cannonsburg																		
Mayslick																		
Menifee																		
Worthington																		
Woodleigh																		
Greysbranch																		
Greenup																		
Oakview																		
Salyersville																		
Adult Education																		
Total	61		106	22							55	72	41	81	28	51	38	76

Table 6 (con't.)

Number of Students Given Lessons at Each School in Kentucky

(Including Logic Students)

Drill-and-practice Mathematics

Kentucky schools	November 1	4	5	6	7	8	11	12	13	14	15	18	19	20	21	22	25	26	27
Breckinridge	29		--	--	70	51	10	--	--	--	--	66	68	56	77	63	80	48	--
Elliottville	2		--	--	12	19	5	--	--	--	--	59	40	56	55	49	70	64	--
Paintsville			--	--			--	--	--	--	--	--	--	9	--	--	18	19	--
Upper Tygart			--	--	29	24	1	--	--	--	--	46	56	8	35	56	63	47	--
Sandy Hook			--	--		11	--	--	--	--	---	25	36	35	38	36	39	35	--
Pikeville			--	--	3	17	--	--	--	--	--	--	--	--	--	--	--	9	--
Louisa			--	--	29	28	--	--	--	--	--	30	63	66	63	46	49	47	--
Flat Gap												4	25	--	--	26	55	6	--
Holy Family												--	--	--	--	--	3	--	--
Pine Acres														--	--	--	--	--	--
Cannonsburg														--	--	--	--	--	--
Mayslick														--	--	--	--	--	--
Menifee																			
Worthington																			
Woodleigh																			
Greysbranch																			
Greenup																			
Oakview																			
Salyersville																			
Adult Education																			
Total	31				143	150	16					230	288	230	268	276			

Table 6 (con't.)

Number of Students Given Lessons at Each School in Kentucky

(Including Logic Students)

Drill-and-practice Mathematics

Kentucky schools	December 2	3	4	5	6	9	10	11	12	13	16	17	18	19	20
Breckinridge	--	--	--	26	--	45	60	32	26	3			43	27	1
Elliottville	--	--	--	56	--	52	64	46	4	28			48	63	57
Paintsville	--	--	--	23	--	24	36	8	21	--			15	18	24
Upper Tygart	--	--	--	44	--	25	69	41	38	29			48	56	46
Sandy Hook	--	--	--	6	--	1	1	1	2	--			1	20	--
Pikeville	--	--	--	--	--	10	26	6	19	--			8	--	--
Louisa	--	--	--	1	--	27	48	11	--	--			24	--	--
Flat Gap	--	--	--	--	--	16	31	14	--	--			--	14	--
Holy Family	--	--	--	--		1	1	1	1	--			2	17	--
Pine Acres	--	--	--	--		--	--	--	--	--			--	--	--
Cannonsburg	--	--	--	--		--	--	--	--	--			--	--	--
Mayslick	--	--	--	--		--	--	--	--	--			--	--	--
Menifee								--	--	--			--	--	--
Worthington								--	--	--			--	--	--
Woodleigh								--	--	--			--	--	--
Greysbranch								--	--	--			--	--	--
Greenup								--	--	--			--	--	--
Oakview								--	--	--			--	--	--
Salyersville								--	--	--			--	--	--
Adult Education								--	--	--			--	--	--
Total				156		200	336	160	111	60			189	215	128

TABLE 7

Number of Students at each Grade Level in Kentucky Schools as of December 30, 1968

School	Grade 1	2	3	4	5	6	7	8	9	Total
Breckinridge	19	20	18	16	19	15	0	0	0	107
Elliottville	22	14	20	34	21	4	0	0	0	115
Paintsville	0	0	0	41	0	0	0	0	0	41
Upper Tygart	0	14	16	4	20	23	0	0	0	77
Sandy Hook	0	0	29	0	26	0	0	0	0	55
Pikeville	0	0	0	0	32	31	0	0	0	63
Louisa	0	29	22	19	13	0	0	0	0	8[illegible]
Flat Gap	0	0	31	16	18	0	0	0	0	65
Holy Family	0	0	0	0	0	21	0	19	16	56
Pine Acres	0	0	0	32	0	0	0	0	0	32
Cannonsburg	0	0	0	0	0	41	0	0	0	41
Mayslick	0	34	25	0	0	0	0	0	0	59
Menifee	0	0	0	0	0	40	0	0	0	40
Worthington	0	0	0	0	0	37	0	0	0	37
Woodleigh	0	0	0	0	32	0	0	0	0	32
Greysbranch	0	0	34	34	0	0	0	0	0	68
Greenup	0	0	0	0	30	0	0	0	0	30
Oakview	0	0	0	0	27	0	0	0	0	27
Salyersville	13	13	10	10	9	14	0	0	0	69
Adult Education	0	0	9	18	10	39	0	0	0	76
Hatfield	0	0	0	0	0	0	20	0	0	20
Fox Valley	0	30	0	0	0	34	0	0	0	64
Inez	0	0	0	0	30	32	0	0	0	62
Prestonsburg	0	0	20	20	0	0	0	0	0	40
Total	54	154	234	244	287	331	20	19	16	1,359

TABLE 8

Number of Students Given Lessons at Each School in Mississippi

(Including Logic Students)

Drill-and-practice Mathematics

Mississippi schools	October 8	9	10	11	14	15	16	17	18	21	22	23	24	25	28	29	30	31
Universal								--	--		--	--	--	22	58		87	147
Otken								147	274		423	422	415	412	240		293	411
Alpha Center															11		2	5
Kennedy															54		80	123
Netterville															6		87	102
Summit																	66	99
Taggart																		26
Westbrook												83	185	222	127		111	317
Franklin																		
Magnolia																		
Fernwood																		
Lillie Mae Bryant																		
Denman Junior High												3	48	61	51		31	67
Eva Gordon																		
Terminal																		
Total								147	274		423	508	648	717	547		757	1,297

Table 8 (con't.) Number of Students Given Lessons at Each School in Mississippi

(Including Logic Students)

Drill-and-practice Mathematics

Mississippi schools	November 1	4	5	6	7	8	11	12	13	14	15	18	19	20	21	22	25	26	27
Universal	139	173	179	178	221	197	212	210	188	218	209	189	112	204	142	169	221	158	126
Otken	380	395	410	429	347	411	402	410	365	357	395	402	306	410	305	389	425	330	374
Alpha Center	2	23	12	17	19	20	10	2	25	32	30	23	35	31	14	32	35	32	29
Kennedy	120	101	127	123	225	126	119	123	66	130	117	128	130	90	98	111	91	81	96
Netterville	135	142	143	139	144	144	146	145	87	144	147	144	66	147	121	135	146	139	136
Summit	126	155	126	132	126	129	130	125	66	128	134	132	47	131	75	128	139	99	117
Taggart	65	104	168	136	190	181	183	187	117	186	179	190	134	187	117	179	189	144	154
Westbrook	252	377	409	302	383	383	393	414	323	399	293	394	173	323	256	365	424	333	242
Franklin			--	--	--	--	--	--	--	29	35	52	77	81	61	83	50	55	41
Magnolia			13	23	34	37	45	--	36	57	58	45	42	31	27	29	55	40	45
Fernwood			3	2	2	17	22	1	29	32	31	32	--	--	--	--	28	29	11
Lillie Mae Bryant			--	--	--	--	--	--	--	19	26	27	27	28	26	27	28	27	28
Denman Junior High	59	54	54	25	57	27	58	65	26	44	54	34	59	54	46	57	49	47	41
Eva Gordon			--	--	--	--	--	--	20	46	29	48	9	30	26	29	31	28	29
Terminal			--	--	--	--	--	--	--	--	--	--	--	--	20	17	18	19	5
Total	1278	1527	1644	1506	1748	1672	1720	1682	1348	1821	1737	1840	1217	1747	1334	1750	1929	1561	1474

Table 8 (con't.)

Number of Students Given Lessons at Each School in Mississippi

(Including Logic Students)

Drill-and-practice Mathematics

Mississippi schools	December 2	3	4	5	6	9	10	11	12	13	16	17	18	19	20
Universal	104	84	27	144	123	155	222	197	186	169			119	163	3
Otken	246	139	86	333	215	254	397	217	250	326			277	297	146
Alpha Center	27	21	17	28	25	29	37	34	32	31			34	31	10
Kennedy	65	22	22	111	70	118	157	139	141	134			109	109	24
Netterville	84	91	15	145	115	71	144	144	143	142			126	108	45
Summit	18	58	42	129	86	--	139	122	109	--			110	102	40
Taggart	99	33	--	136	96	--	199	189	167	--			137	116	102
Westbrook	229	68	55	340	14	--	373	310	308	67			282	339	105
Franklin	12	25	26	35	--	--	98	83	48	82			63	41	--
Magnolia	29	19	18	1	--	--	56	31	44	27			27	28	--
Fernwood	--	--	2	--	--	--	1	3	30	32			31	32	--
Lillie Mae Bryant	24	6	12	18	--	--	--	--	--	--			--	--	--
Denman Junior High	42	23	5	63	--	--	61	48	43	41			31	28	21
Eva Gordon	2	14	9	30	--	--	38	43	27	23			43	40	1
Terminal	8	19	13	18	--	--	21	5	19	10			14	13	--
Total	989	622	349	1531	744	627	1943	1558	1546	1084			1403	1447	497

B. Drill-and-practice Reading Program

1. Strand Exercises

The reading curriculum consists of five parallel strands. The rationale for the subject matter of the strands was described in the last quarterly report. Structurally, the curriculum strands consist of sections dealing with one set or two or three items in a linear format. The section provides drill and practice on the set of items in the form of either two or three exercises that increase in difficulty. Sections are grouped into chapters, and chapters into books.

Exercises in the strands progress in series of trials. A trial represents one cycle through the set of items (i.e., one encounter with each item). These encounters, or presentations, have a problem phase, a response phase, and a feedback phase. The problem phase begins with the selection of a new item, followed by computer output to the student terminal. The output may be printed letters by the specially equipped Model-33 teletypes or a nonprinted operation (e.g., several line feeds). In either case, the student also hears a computer-generated audio message.

The response phase permits the student to type one of five alternatives: the correct key(s), CANCEL, ENTER, some other key(s), or no key. To register a response, the student must terminate his response by striking either CANCEL or ENTER. Otherwise, his response is considered as an overtime, just as if he had struck no key.

The feedback phase consists of (a) a decision by the computer about a response, and (b) computer-directed typing to the student. In the case of wrong answers and overtimes, the correct answer is typed along with the appropriate audio message. The decision is made by comparing results of the response with a preset criterion. The phonics strand uses a single criterion that requires consecutive errorless trials only, though the number of such trials varies according to the number of items in the set. Elsewhere, evaluation is based on a double criterion which specifies two conditions: (a) n successive correct responses to each item, and (b) n errorless trials concluding the exercise. In any event, if the criterion is met, the student advances to the next exercise, and perhaps a new section. If criterion is not met, the computer randomly selects a new item for a new presentation, except in the case of CANCEL when the item is simply re-presented. A fourth CANCEL on any item (no other items intervening) acts as an overtime.

Tables 9 through 12 describe the sequence following alternative responses. Brackets enclose nonprinted operations.

2. Description of the Strands

Strand Ø: Readiness. This strand familiarizes students with the use of teletypes. Having completed classroom activities with a simulated keyboard, the students begin to apply the simple mechanics of the reading teletype program.

The readiness strand consists of three types of exercises. First, the student learns the use and location of the ENTER and CANCEL keys. With an audio request and appropriate feedback after each response, the student drills on use of the ENTER key until he meets criteria for the exercise, then he repeats the process of the CANCEL key.

	Display	Audio
Ex. 1:	(no display)	Type the enter key

In the succeeding readiness exercises, the student receives an audio reminder to enter his response whenever he types an answer and fails to enter it.

The second exercise provides practice with the space bar and the YES and NO keys. The student is requested to type these keys in various orders until he meets criteria for the task.

	Display	Audio
Ex. 2:	(no display)	Type the yes key

The last readiness exercise involves a discriminative use of letters. A number of letters such as MW and CG are selected and from each pair we form four items which also are pairs; for example, MM, MW, WM, WW. The presentation of items is of the form:

	Display	Audio
Ex. 3:	MW	Are the letters the same? Type yes or no.

The four items are presented in random order until criteria is met. Again, the student is reminded to use the enter key if he forgets to do so.

TABLE 9

Sequence of Exercises for the Reading Strands

Strand	Exercise	Criterion[1]	Sequence	Correct answer	Overtime	Wrong answer	Cancel
Ø Readiness	1. Enter Cancel	3,0	Problem:	Teletype: (no display)	Audio: "Type the Enter key"		
			Student:	(enter)	(no response)	L	(cancel)
			Teletype:	Yes	Time	////	(no display)
			Audio:	"Good"	- - - -	"Wrong"	"Type the Enter key"
	2. Yes No Space	2,1	Problem:	Teletype: (no display)	Audio: "Type the space bar"		
			Student:	(space)	(See description of the special reminder routine in the text)	(yes)	(cancel)
			Teletype:	Yes		////	(no display)
			Audio:	"Good"		"Wrong"	"Type the space bar"
	3. Same-different pairs	2,1	Problem:	Teletype: M W	Audio: "Are the letters the same? Type Yes or No"		
			Student:	(no)	(See description of special reminder routine in the text)	(yes)	(cancel)
			Teletype:	Right		////	(no display)
			Audio:	"Good"		"Wrong"	"Are the letters the same? Types yes or no."

[1] First number = Successive correct responses to an individual item.
Second number = Consecutive errorless trials required for the terminal trials of an exercise.

TABLE 10

Sequence of Exercises for Reading Strands

Strand	Exercise	Criterion[1]	Sequence	Correct answer	Overtime	Wrong answer	Cancel
I. Letter identification and punctuation	1. Single letter	3,1		Problem:	Teletype: t Audio: "Type t"		
			Student:	t	[no response]	m	[cancel]
			Teletype:	YES	TIME t	//// t	t
			Audio:	---	"t"	"t"	"Type t"
	2. Triplet	3,1		Problem:	Teletype: m o t Audio: "Type t"		
			Student:	t	[no response]	m	[cancel]
			Teletype:	YES	TIME t	//// t	m o t
			Audio:	---	"t"	"t"	"Type t"
	3. No display	3,1		Problem:	Teletype: [line feeds] Audio: "Type t"		
			Student:	t	[no response]	o	[cancel]
			Teletype:	YES	TIME t	//// t	[line feeds]
			Audio:	---	"t"	"t"	"Type t"
II. Word identification	1. Single word	2,1		Problem:	Teletype: Tom Audio: "Type Tom"		
			Student:	Tom	[no response]	Toj	[cancel]
			Teletype:	YES	TIME Tom	//// Tom	Tom
			Audio:	---	"Tom"	"Tom"	"Type Tom"
	2. Triplet	2,1		Problem:	Teletype: Tom ride Pony Audio: "Type Tom"		
			Student:	Tom	[no response]	ghj	[cancel]
			Teletype:	YES	TIME Tom	//// Tom	Tom ride Pony
			Audio:	---	"Tom"	"Tom"	"Type Tom"

[1] First number = Successive correct responses to an individual item.
Second number = Consecutive errorless trials required for the terminal trials of an exercise.

TABLE 11

Sequence of Exercises for Reading Strands

Strand	Exercise	Criterion[1]	Sequence	Correct answer	Overtime	Wrong answer	Cancel
III. Phonics	1. Single unit (first four sections only)	2,1	Problem:	Teletype: -in Audio: "Type /in/ as in pin"			
			Student: Teletype: Audio:	in <u>or</u> -in YES ---	[no response] TIME in "/in/"	on //// in "/in/"	[cancel] -in "Type /in/ as in pin"
	2. Triplet--final unit	2,4 3,2	Problem:	Teletype: -it -in -ip Audio: "Type /in/ as in pin"			
			Student: Teletype: Audio:	in <u>or</u> -in YES ---	[no response] TIME in "/in/"	on //// in "/in/"	[cancel] -it -in -ip "Type /in/ as in pin"
	Triplet--initial unit	same as III - 2	Problem:	Teletype: pi- ti- ni- Audio: "Type /pi/ as in pin"			
			Student: Teletype: Audio:	pi <u>or</u> pi- YES ---	[no response] TIME pi "/pi/"	ni- //// pi "/pi/"	[cancel] pi- ti- ni- "Type /pi/ as in pin"
	3. Word completion	same as III - 2	Problem:	Teletype: -it -in -ip p-- Audio: "Make pin"			
			Student: Teletype: Audio:	pin YES ---	[no response] TIME pin "pin"	nip //// pin "pin"	[cancel] -it -in -ip p-- "Make pin"

[1] First number = Successive correct responses to an individual item.
Second number = Consecutive errorless trials required for the terminal trials of an exercise.

TABLE 12

Sequence of Exercises for Reading Strands

Strand	Exercise	Criterion[1]	Sequence	Correct answer	Overtime	Wrong answer	Cancel
IV. Spelling patterns	1. Single unit	2,1		Problem:	Teletype: Audio:	cat "Type cat"	
			Student: Teletype: Audio:	cat YES ---	[n.r.] TIME cat "cat"	bat //// cat "cat"	[cancel] cat "Type cat"
	2. No display	2,1		Problem:	Teletype: Audio:	[line feeds] "Type cat"	
			Student: Teletype: Audio:	cat YES ---	[n.r.] TIME cat "cat"	bat //// cat "cat"	[cancel] [line feeds] "Type cat"
V. Word Meaning	(In preparation)						

[1]First number = Successive correct responses to an individual item.

Second number = Consecutive errorless trials required for the terminal trials of an exercise.

Strand 1: Letter identification. The sequence of the first letters is based on the sequence required for the sight vocabulary presented in the early levels of Strand 2. All letters, including both lower case and upper case, plus the common punctuation symbols, are taught in the letter-identification strand.

Three types of exercises are used throughout the letter-identification strand. In the first exercise, a letter is displayed on the printout and the student is requested to type the same letter.

	Display	Audio
Ex. 1:	n	Type the letter n

The exercise is repeated for another letter. The letters appear in random order until the student achieves criterion for each letter.

After the student has achieved criterion for each of the three letters in the set, he proceeds to the second type of exercise in the strand. In this exercise, he again must achieve criterion for each letter in the set. (A description of criterion is given later in this report.)

	Display	Audio
Ex. 2:	i n a	Type the letter n

After each problem, the order of the three letters is randomly changed, and the exercise is repeated for another letter. Upon achieving criterion for each of the letters, the student proceeds to the third exercise.

	Display	Audio
Ex. 3:	(No display)	Type the letter n

When he achieves criterion on Exercise 3, he proceeds to the second set of three letters.

Throughout the drill-and-practice materials, a correct response advances the student to the next problem. In addition, the student receives randomly scheduled audio reinforcement messages. Variable-interval reinforcement is useful for establishing response rates that are stable, uniform, and resistant to extinction. If a student responds incorrectly or exceeds the time allowed for a response, the teletype displays the correct response and proceeds to the next problem. A sample page of curriculum appears in Table 13.

When a student meets criterion on a specific number of letters (those required in the early sight vocabulary of Strand 2), he begins Strand 2. At this point, the student will work simultaneously in both Strands 1 and 2, but at different levels of difficulty within each strand.

TABLE 13

Letter Teaching Strand Curriculum for Stanford-Ravenswood Reading

Key Page of I.D. Numbers

Series:	B		Task	Book	Chap.	Sec.	Ex.
a	r	n	L	2	A	1	S
"	"	"	L			1	T
"	"	"	L			1	N
m	i	u	L	2	A	2	S
"	"	"	L			2	T
"	"	"	L			2	N
A	R	N	L	2	B	1	S
"	"	"	L			1	T
"	"	"	L			1	N
M	I	U	L	2	B	2	S
"	"	"	L			2	T
"	"	"	L			2	N

Note: L - letter identification task
S - single item presentation
T - triplet presentation
N - no teletype display

Strand 2: Sight-word recognition. The second strand provides drill and practice on vocabulary introduced and taught by the classroom teacher. The drill-and-practice vocabulary is introduced in each of the three specified reading texts chosen by the Ravenswood City School District for the primary grades.

Experience has indicated the usefulness of picture and content cues, as well as drill and practice on the printed word itself. While the classroom teacher introduces and teaches each word with both content and picture cues, the teletype is a highly valuable supplement that provides concentrated drill on the word itself.

The vocabulary is presented in sets of three words in two different exercises. Each exercise takes the form of a paired-associate task. The association of the sound (spoken word) with the visual stimulus (the written word) forms the basis of the following exercises. The first exercise gives the student two cues: the spoken word and the written word.

	Display	Audio
Ex. 1:	cup	Type cup

When the student has achieved criterion for each of the three words forming the set, he begins Exercise 2.

	Display	Audio
Ex. 2:	cup nut ham	Type cup

When the child has met criterion for each new word in each of the two exercises, he proceeds to the next set of three words as shown in the curriculum sample in Table 14.

Again, the student must meet criterion or exhibit mastery in each of the exercises over all the words in the set before he can proceed to another set.

Strand 3: Phonics. When the student has shown mastery of a specified amount of sight vocabulary by completing a predetermined number of levels in Strand 2, he begins Strand 3 with drill and practice in phonics.

It is again emphasized that each strand is separate from every other strand, but they are related. For example, entry into Strand 3 is dependent on the student's progress in Strand 2. Once a student enters a strand, he is allowed to proceed at a rate commensurate with his ability. The strand approach to drill and practice in reading skills permits individual word-attack development.

TABLE 14

Sight Word Strand Curriculum for Stanford-Ravenswood Reading

Key Page of M.D. Numbers

Series: A.			Task	Book	Chap.	Sec.	Ex.
job	wag	wax	W	2	C	1	S
"	"	"	W			1	T
cry	mud	bath	W	2	C	2	S
"	"	"	W			2	T
path	mad	well	W	2	D	1	S
"	"	"	W			1	T
yell	fish	she	W	2	D	2	S
"	"	"	W			2	T
get	pack	rang	W	2	E	1	S
"	"	"	W			1	T
me	doll	hand	W	2	E	2	S
"	"	"	W			2	T

Note: W - sight word task
S - single item presentation
T - triplet presentation

Exercises in the Phonics Strand follow the sequence of phonics work for the specified reading series texts and concentrate on initial and final consonants and medial vowels. A departure is made, however, from traditional phonics exercises in that the students are never required to rehearse or identify consonant or vowel sounds in isolation, but rather in combinations of vowel-consonant or consonant-vowel units.

The following exercises are used in Strand 3.

Final Consonant

	Display	Audio
Ex. 1:	-in	Type /-ɪn/ as in pin
Ex. 2:	-in -ip -it	Type /-ɪn/ as in pin

Initial Consonant

	Display	Audio
Ex. 1:	-ca	Type /kæ-/ as in cat
Ex. 2:	ca- ba- fa-	Type /kæ-/ as in cat

The procedure is similar to that for Strands 1 and 2. The student again works with a set of three units. He must meet criterion for each set of units in the exercise before proceeding to the next set. Table 15 is an example.

The audio reinforces the sound values with randomly selected examples from a matrix of three sample words--two monosyllabic, and as often as possible, an identifiable polysyllabic word.

Strand 4: Spelling patterns. The spelling pattern strand is designed to provide direct and explicit practice with English spelling patterns and emphasizes as many as possible of the regular grapheme-phoneme correspondences that occur in the graphic representation of English. All the spelling patterns presented in this strand were chosen from words already taught in the sight-word strand.

The following exercises are used in this strand.

	Display	Audio
Ex. 1:	cat	Type cat
Ex. 2:	(No display)	Type cat

A section for this strand consists of three monosyllabic words, such as cat, bat, and rat. These three words embody the same spelling pattern, at, which in each of these words corresponds to the same phoneme, /æt/.

TABLE 15

Phonic Strand Curriculum for Stanford-Ravenswood Reading Program

Key Page of I.D. Numbers

Example words for audio use

Series: B				Task	Bk.	Ch.	Sec	Ex.
-em	-ep	-eg leg		P	12	1	1	T
stem	step	beg	-em -ep -eg					
them	pep	peg		P	12	1	1	C
-end defend	-ent parent	-est test		P	12	1	2	T
mend	rent	rest	-end -ent -est					
send	tent	nest		P	12	1	2	C
pa- package	ca- cabin	ha- happy		P	12	M	1	T
pat	cat	hat	pa- ca- ha-					
pad	can	ham		P	12	M	1	C
ga- gasoline	fa- family	sta- standing		P	12	M	2	T
gas	fat	stand	ga- fa- sta-					
	fan	stamp		P	12	M	2	C

Note: P - phonic task
T - triplet presentation
C - completion presentation

Once again, when the student meets criterion for each of the two or three words in the set, he proceeds to the next set of words as shown in Table 16.

Strand 5: Word meaning. When the student has met criterion over a specified number of Strand 2 levels (sight vocabulary of approximately 50 words), he enters Strand 5.

Strand 5 provides drill and practice on word meaning to supplement the initial introduction of vocabulary in the classroom and therefore helps to maintain that vocabulary. All the words used in Strand 5 were previously mastered by the students by word recognition. Exercises are of three basic types: categorization; synonyms and antonyms; and phrase and sentence completion. Three examples of the first type of exercise are shown below.

	Display	Audio
Ex. 1:	dog cat run	Type the word that is something you can do.
	hat dog run	Type the word that is an animal.
	cat dog pig hat	Type the word that doesn't belong.

When the student has met criterion for each word in a set of three words, he proceeds to Exercise 2.

	Display	Audio
Ex. 2:	night day	Type the word that means the opposite of night.

In the early levels of Strand 5 the child selects his answer from two choices. Later in the strand he selects his answer from three or four choices. When he has again met criterion for each word, he begins Exercise 3.

	Display	Audio
Ex. 3:	Tom paints. Tom is a ____. painter painting	Type the missing word.

TABLE 16

Spelling Pattern Curriculum for Stanford-Ravenswood Reading Program Key Page of I.D. Numbers

Example words for audio use

Series: A				Task	Bk.	Chap.	Sec.	Ex.
drum	gum	hum	-um	S	18	W	1 1	s N
rut	nut	cut	-ut	S	18	W	2 2	s N
cup	cup	pup	-up	S	18	W	3 3	s N
run	gun	sun	-un	S	18	X	1 1	s N
bug	rug	tug	-ug	S	18	X	2 2	s N
thud	mud	bud	-ud	S	18	X	3 3	s N
lump	jump	dump	-ump	S	18	Y	1 1	s N
dust	crust	must	-ust	S	18	Y	2 2	s N
grunt	hunt	stunt	-unt	S	18	Y	3 3	s N
trip	trick	trim	tri-	S	18	Z	1 1	s N
grin	grip	grin	gri-	S	18	Z	2 2	s N
spins	spill	spin	spi-	S	18	Z	3 3	s N

Note: S - spelling patterns
s - single item presentation
N - no teletype display

Exercise 3 provides use of meaning clues or inference from phrase and sentence context and permits variety within this learning task.

The curriculum for the drill-and-practice reading strands has been completed through Strand 4, Spelling Patterns, and is now in the process of being entered on the PDP-1 system. The curriculum will then be processed by a preprocessing program that prepares it for use on the PDP-10.

Efforts will be made to complete the curriculum for the Word Meaning Strand during the next reporting period.

3. Teacher Reports

The average student spends from 2 to 5 minutes in reaching criterion on an exercise. A slow student may take much longer. On the other hand, the length of time a student is allowed to remain on an exercise is left to the discretion of the classroom teacher. A maximum-time parameter for each exercise is set at 12 minutes by the program, but it may be varied by the teacher. The program produces a daily list of students whose total time on any given exercise has exceeded the maximum-time parameter. The teacher may then work with these students on an individual tutorial basis, or she may remove a student from the drill program for an indefinite time.

A complete status report for an entire class in all strands, an entire class in a particular strand, an individual student in a particular strand, or an individual student in all strands is available to the teacher at any time. These reports are obtained by entering a simple set of commands on a student terminal by the teacher or proctor.

The request input indicates whether information is desired on student(s) progress for all strands, A; or for individual strands (Letter identification, L; Sight words, W; Phonics, P; Spelling patterns, S; Word meaning, M).

Teacher code	A (class, all strands)	plus time cut off
		X = 0 to 9 min.
	student numbers and strand code L, W, P, S, or M.	Y = 10 to 19 min.
		Z = 20 min. or more

An appropriate time limit for the class or particular students is established by the teacher, based on her knowledge of the time students have spent on the teletypes or on her particular planning need. The code designations are (a) X with a value of zero to 9 minutes on a strand; (b) Y with a value of 10 to 19 minutes; and (c) Z with a value of 20 minutes or more.

Obviously, a student will not work on a given exercise for an hour and 20 minutes, but the maximum time limit depends on the particular exercise. A maximum-time parameter has not been fixed in the program; rather, the teacher, because of her more intimate knowledge of the students, makes this decision. If, for example, the teacher feels that Johnny should not stay on an exercise longer than 9 minutes, she would set a cut-off time for Johnny from 10 to 19 minutes, or Y. If the report indicates that Johnny has been on the exercise for 10 minutes or more, the teacher may work with Johnny on a one-to-one tutorial basis to get him over a difficulty, or she may remove him from the program for as long as she felt was necessary.

Since the sequencing of elements within a given strand is closely keyed to a particular reading series, the status report informs the teacher of each student's current placement in the drill program by unit and page number in the classroom reading series. For example, a status report for John Jones and Mary Smith in the sight-word strand might be of the following form:

Name	Strand	Ex.	Items	Time	Series	Page
John Jones	sight words	triplet	hat,bat,sat	15	B.	twelve
Mary Smith	sight words	single	fill	19	A.	twenty

The above report is a brief way of saying that John Jones spent 15 minutes in the sight-word recognition exercise and achieved criterion for all new words introduced through page 12 of his primer.

At a glance the teacher notes the area of difficulty, the time devoted to the strand, and the particular item(s) in the exercise. These data give direction to areas of reteaching and/or an accurate up-to-date evaluation of the mastery of basic reading skills.

4. Criteria

There are two types of criteria: one based on runs of consecutive correct answers to individual items; the other based on consecutive correct answers within an exercise (set of 3 presentations). There are four criterion counters in each exercise, three of which tally consecutive correct answers for each of the items and one which tallies consecutive correct answers for the exercise as a whole. A wrong answer to a particular item, therefore, will zero the criterion for that item, leave untouched the remaining item criterion counters, and zero the trial criterion counter. It should be noted that these criteria are based on consecutive correct answers--2 successive correct answers or 3 successive correct answers. As an example, in the set of three letters, T, O, and M, criterion might be 2 consecutive correct answers for each of the letters and 2 consecutive correct answers for the last set of 3 items. The following protocols of responses would then occur (ignoring the random order of presentation each time):

T O M,	or	T O M,	or	T O M
c w w		c c c		c w c
c c w		c c c		c c w
c w w				c c c
w c c				c c c
c c c				
c c c				

Thus, the criterion counters determine when a student moves from one exercise to another within a section. The criterion for leaving one strand and going to another, however, does not depend on the number of correct answers, but is determined by the amount of time the student has spent on that strand. Specifically, after each exercise (set of three presentations), information taken from the criterion counters is used to determine whether a student advances to a new exercise in the same section or another section in the same strand. The amount of time a child works in each strand and the total amount of time he spends on the machine are variables specified by the classroom teacher.

The criterion data are used for restart points. There are no restrictions of where in the curriculum a student can be taken off the machine. Whenever a student is restarted on a new day or in another strand, the appropriate timers and counters appear exactly as they did when the student signed off the machine or was taken out of the strand. The only exception to this rule is the following: if a student is removed in the middle of an exercise, he begins, not where he left off, but at the top of the exercise with a newly randomized presentation order of the same 3 items he was working on before he was removed. The status of all the timers and counters is preserved as they were at the time the student stopped his exercise. For restarts of any kind in each of the 5 strands, then, there exists a trial criterion counter, the strand timer (which stores the amount of time a student spent in a strand), the item criterion counter for each of the items (usually 3), and the status of the completion timer, which is turned on whenever the student reaches criterion on an item. The number of item presentations made to the student and the number of correct answers the student makes to the items (regardless of whether the correct answers were consecutive or not) are stored.

A running account of the following information is available for each student in the reading program:

1. The status of the six time parameters, one for each of the 5 strands plus one for the amount of time a student is to spend on the machine each day. These are not specified every time the student signs on the machine, but can be reset if desired.
2. The status of two timers, one which accumulates the total time a student has spent in the strand he is presently working on (this is zeroed when he leaves one strand for a new one), and another which accumulates the total time a student has spent in the exercise he is presently involved with (this is zeroed when the student reaches criterion for the exercise).
3. A four-tuple display which keeps the following information: (a) the number of presentations or exposures to an item in an exercise; (b) the total number of correct answers to an item in a section; (c) the length, if any, of the last run of consecutive correct answers to an item in an exercise; and (d) the status of item criterion.
4. Five counters, one for each strand, which tally the length, if any, of the last run of consecutive errorless trials the student achieved.

5. Review, Variety, and Allocation of Time

The provisions for variety and review in a daily strand assignment, the proportion of time allotted to each assigned strand, and the division of time within a strand between sections presenting new material and sections reviewing material previously studied are unlimited.

Four of the five main strands planned have been designed and are in the process of being constructed. The fifth, involving word-meaning exercises, is still in the planning stage. Since it comes last in the strand sequencing, the description of the process of assigning strands will be based on the letter-identification learning, sight-word, phonics, and spelling-pattern strands.

There is no convincing a priori reason for assigning more time to one strand than another. Therefore, equal time each day, on the average, is apportioned to each assigned strand this year. The qualification "on the average" is made because there is a minimum time which should be spent on each strand in order to insure that the student has time to warm up and get into the material. To accommodate all the students in the program, however, the total length of the drills may have to be shortened to permit assignment of a satisfactory amount of time to all strands every day. Should this be the case, it is preferable to allow enough time for each strand worked on and to alternate days on strands. In this way, over a longer period of time, the strands receive equal coverage.

A systematic review is an integral part of the design of each strand. Review consists of reteaching to the same criterion the highest numbered (most difficult) exercise of each of the preceding sections. Although the format is subject to chance, the main features of the review system are:

1. A maximum proportion of time (e.g., 1/4) is devoted to review.
2. A maximum lag between the last section of new material completed and the section to be reviewed (e.g., 10 seconds) is determined.
3. A week's drill time is broken into two blocks. The first block of time, 4/5, is devoted to new material. As much of the second block as required is devoted to review. Any remaining time is devoted to new material in the same strand.
4. If the last unreviewed section is no more than 10 sections back, it is reviewed first. Otherwise, some reviews are skipped and the tenth section back is reviewed first. Once started, a review progresses through all of the last 10 sections or until time is up.

Figures for the maximum proportion of time devoted to review, 1/4, and the maximum lag between new and review material, 10 sections, are not yet fixed.

6. Systems

The reading curriculum will pass through three stages:

1. The development of a prototype reading program written for the PDP-1 system which would drive a single student terminal through the reading curriculum.
2. The translation of this prototype to PDP-10 assembles language as soon as the PDP-10 becomes available.

3. The interface of the PDP-10 program with the generalized "drill-driver" program which will enable the basic prototype to drive many student terminals through the curriculum on a time-shared basis.

During the last quarter the PDP-1 prototype was completed and work was begun to translate the PDP-1 prototype into a program that could run on the PDP-10 system and to interface the PDP-10 program with the drill driver now in the final debugging stage. Completion of the translation to PDP-10 assembler language depends on the availability of the PDP-10, and completion of the interface of the reading program with the drill driver is predicated upon the completion and debugging of the drill-driver program. Essentially, the drill driver will treat the reading program as a subroutine and the reading program will, in turn, have access to such necessary time-shared drill-driver routines as teletype input/output, data collection and storage, and student restart routines.

7. Audio

The recording for the digitized audio was begun. Rather than transferring tape-recorded words to disk storage, it was decided to record on-line directly into core and then to disk storage. Time limitations restricting the availability of the PDP-1 could reverse this decision. Sound quality via the two techniques is equally acceptable, however, the on-line speech editor program simplifies the task of recording parts of words exactly as they sound in context of whole words (a feature especially valuable in the phonic and spelling strands). A word is recorded and filed with an I.D. number. This word is retrieved and cut to a needed word part (-ack from the word back) and then filed under its identifying number. Each whole word in the master dictionary of approximately 4,500 words is assigned an even octal number. Odd numbers are reserved for part-words. These numbers serve as identifiers to retrieve the location and the length of the computer words stored on the disk. Using these identifiers, the computer converts the words into audio messages.

The recording is done by a qualified staff member, who is a member of the American Speech and Hearing Association.

C. Logic and Algebra Program

1. The First-year Program

Most of the revised first-year lessons were coded. The curriculum will be presented as soon as the new PDP-10 drill driver and logic program become operative.

Since students have experienced difficulty in applying the "replace equals" rule, we have changed the format. In following the old rule, the student simultaneously had to remember two line numbers and an occurrence number in the correct order. In addition, the term to be replaced had to be on the left side of the replacement equation. With the new format, the machine helps the student remember how to input the necessary information for application of the rule. The replacement will be made regardless of the order of the terms around the "=." For an example of the old and new formats see Table 17.

Error messages that up to now have been tedious, difficult to understand, and often irrelevant to the actual error have also been revised completely.

2. The Second-year Program

Lesson writing and coding. Lessons 220 to 232 were rewritten and coded on the basis of observations made last year and during the quarter. Also written and coded were new lessons 233 to 243. Effort has been made to relieve the curriculum of its tendency of becoming tedious. Stories and puzzles were added and axioms and theorems were simplified. The simplifications should eliminate steps in student proofs that are not central to the proof idea. Table 18 gives a revised and extended lesson outline. Work has continued on teacher's manual as lessons have been coded and debugged. The manual currently covers lessons 201 to 223.

Student progress. Students at Walter Hays continued work on algebra, with the fastest student now on lesson 227 and the slower students in lessons 217 and 220. No other students began work on algebra during the quarter.

3. Programming

Programming for the PDP-10 version of the logic/algebra program is nearing completion. All of the programs have been written. Debugging will begin as soon as a suitable interface is available with the PDP-10 drill driver.

The new programs maintain full compatability with the problem formats for the PDP-1 programs. There are, however, additional forms of problem types that were designed for greater pedagogical flexibility. There is, for example, a counterexample mode that emphasizes the proof technique. There are also modes

TABLE 17

Examples of Old and New Formats of "Replace Equals"

	Format*	Comment
Old	Derive: $a + 7 < b + 9$ P (1) $a + 7 < a + 9$ P (2) $b = a$ 2CE1 (3) $a = b$ 1.3RE2 (4) $a + 7 < b + 9$	step to get term to be replaced on the left
New	Derive: $a + 7 < b + 9$ P (1) $a + 7 < a + 9$ P (2) $b = a$ 1RQ REP: a OCC: 2 BY: b (3) $a + 7 < b + 9$	REP asks student what term to replace OCC asks student which occurrence of the term to replace BY asks student what the term is to be replaced by

* Student responses are underlined.

TABLE 18

Logic and Algebra Course Outline

Second Year

Lesson Number	Topic
201	Recognition of true and false sentences; recognition of types of sentences; equations; inequalities.
202	Review of atomic and molecular sentences; conditionals; when a conditional is true.
203	AA: affirm the antecedent; Truth value of conditionals as related to truth value of antecedent and consequent.
204	ND: number definition.
205	WP-CP: working premise and conditional proof.
206	WP-CP.
207	Valid rule of inference.
210	CE: commute equals.
211	AE: add equals.
212	SE: subtract equals.
213	LT: rule of logical truth.
214	Review problems; RE: replace equals (long form).
215	RE: replace equals (short form).
216	CA: commute addition axiom A + B = B + A. short form of CA.
217	AS: associate addition axiom (A + B) + C = A + (B + C); AR: associate addition right; AL: associate addition left.
220	Z: zero axiom A + 0 = A.
221	N: negative number axiom A + -B = A - B.

Table 18 (con't.)

Lesson Number	Topic
222	AI: additive inverse axiom $A + -A = 0$.
223	Theorem 1: $0 + A = A$; Theorem 2: $(-A) + A = 0$; Theorem 3: $A - A = 0$; Theorem 4: $0 - A = -A$; Theorem 5: $0 = -0$; Theorem 6: $A - 0 = A$.
224	Theorem 7: $A + B = A + C \rightarrow B = C$; Theorem 8: $A + B = C \rightarrow A = C - B$; Theorem 9: $A = C - B \rightarrow A + B = C$.
225	Theorem 10: $A + B = 0 \rightarrow A = -B$; Theorem 11: $A = -B \rightarrow A + B = 0$; Theorem 12: $A + B = A \rightarrow B = 0$.
226	Theorem 13: $-(-A) = A$; Theorem 14: $(-(A + B)) + B = -A$; Theorem 15: $-(A + B) = (-A) - B$; Theorem 16: $(-A) - B = (-B) - A$; Theorem 17: $-(A - B) = B - A$
227	Theorem 18: $(A - B) - C = A + ((-B) - C)$; Theorem 19: $(A - B) - C = A - (B + C)$; Theorem 20: $A + (B - A) = B$; Theorem 21: $A - (A + B) = -B$; Theorem 22: $(A - B) + (B - C) = A - C$.
230	CM: commute multiplication axiom $A \times B = B \times A$.
231	MU: multiplication by unity axiom $A \times 1 = A$. Theorem 30: $1 \times A = A$.
232	ME: multiply equals; DE: divide equals.
233	MI: multiplicative inverse axiom $\neg A = 0 \rightarrow A \times (1/A) = 1$; Theorem 31: $\neg A = 0 \rightarrow (1/A) \times A = 1$.
234	U: unity axiom $\neg 1 = 0$. IP: Indirect Proof.

Table 18 (con't.)

Lesson Number	Topic
235	FR: axiom for fractions $\neg$ B = 0 → A/B = A x (1/B). Theorem 32: 1/1 = 1; Theorem 33: A/1 = A.
236	LC, RC Theorem 34: $\neg$ B = 0 & A x (1/B) = C → A = B x C; Theorem 35: $\neg$ A = 0 & B = 1/A → A x B = 1.
237	Theorem 36: B = 1 & $\neg$ A = 0 → A x B = A. Some fun and games.
240	DL: distributive axiom; Theorem 37: A x 0 = 0.
241	MS: associate multiplication axiom (A x B) x C = A x (B x C); MR: associate multiplication right; ML: associate multiplication left.
242	Theorem 38: A x B = 0 & $\neg$ A = 0 → B = 0; Theorem 39: $\neg$ A = 0 → C/A = 0; Theorem 40: $\neg$ A = 0 & A x B = A x C → B = C.
243	Theorem 41: $\neg$ B = 0 & A = B x C → A x (1/B) = C; Theorem 42: $\neg$ A = 0 & A x B = 1 → B = 1/A; Theorem 43: $\neg$ A = 0 & A x B = A → B = 1.
244	Theorem 44: (A + B) x (C + D) = (A x C + A x D) + (B x C + B x D). Theorem 45: A x (-B) = -(A x B); Theorem 46: (-A) x B = -(A x B); Theorem 47: (-A) x B = A x (-B).
245	Theorem 48: (-A) x (-B) = A x B; Theorem 49: A x (B - C) = A x B - A x C; Theorem 50: -A = (-1) x A.
246	FC, DN, more on IP.
247	Truth assignment mode.
250	Counterexample mode.

Table 18 (con't.)

Lesson Number	Topic
251	Axiom 13: $A < B \rightarrow \neg B < A$; Theorem 60: $\neg A < A$; Problems using CEX mode.
252	Theorem 61: $A = B \rightarrow \neg A < B \,\&\, \neg B < A$; Theorem 62: $A < B \rightarrow \neg A = B \,\&\, \neg B < A$:
253	Axiom 14: $A < B \rightarrow A + C < B + C$; Theorem 63: $A < 0 \rightarrow 0 < -A$; Theorem 64: $0 < -A \rightarrow A < 0$.
254	Theorem 65: $A + B < B + C \rightarrow B < C$; Theorem 66: $A < B \rightarrow -B < -A$.
255	Theorem 67: $-B < -A \rightarrow A < B$; Theorem 68: $A + (-B) < A + (-C) \rightarrow C < B$.
256	Theorem 69: $C < B \rightarrow A + (-B) < A + (-C)$; Theorem 70: $(A < 0 \,\&\, B < C) \rightarrow A \times C < A \times B$.
257	Theorem 71: $(A < 0 \,\&\, A \times B < A \times C) \rightarrow C < B$; Theorem 72: $(0 < A \,\&\, A \times B < A \times C) \rightarrow B < C$;
258	Theorem 73: $0 < 1$; Theorem 74: $A < 0 \rightarrow (1/A) < 0$.
259	Axiom 16: $(A < B \,\&\, B < C) \rightarrow A < C$.
260	Theorem 75: $(0 < A \,\&\, B < 0 \,\&\, C < 0) \rightarrow A \times B < B \times C$; Theorem 76: $(A < 0 \,\&\, 0 < B \,\&\, 0 < C) \rightarrow A \times B < B \times C$.
261	Theorem 77: $0 < (A/B) \rightarrow 0 < A \times B$; Theorem 78: $0 < A \times B \rightarrow 0 < (A / B)$.
262	Axiom 17: $\neg A = B \rightarrow A < B \vee B < A$; Theorem 79: $(\neg A = B \,\&\, \neg A < B) \rightarrow B < A$.
263	Summary of Course.

that permit the student to respond with the correct truth values for logical expressions and to assign numeric (and/or logical) values to make desired statements either true or false.

D. Second-year Russian Program

Instruction began in September for 19 students enrolled in the second-year Russian language course. Out of 19 students, 12 continued from the first-year course offered in 1967-68 at Stanford University, and 7 took the Stanford placement test to qualify for the second-year course and were new to computer-based instruction.

Thirty-nine lessons, including review lessons, were available for the quarter and averaged 45 minutes in length. Classes were held Monday through Friday.

Homework and study sheets for Lessons 1 through 39 were distributed to the students as they progressed through the lessons. The homework involved translating English sentences into Russian while the study sheets dealt with new grammar and new vocabulary pertinent to the day's lesson. To develop speech and the ability to write correctly what is heard, the students occasionally were given an option at the conclusion of a teletype lesson to take dictation or to practice pronunciation. These exercises were recorded, alternately, at the end of the same tape as the audio portion of the regular teletype audio lessons.

On alternate Fridays, students took written quizzes, or read from handwritten or typed scripts. Their pronunciation was corrected and suggestions were made for improvement. Students were also given midterm and final examinations. Table 19 gives a comparison of the common portion of the final examination taken by both the computer-based class and the conventionally taught class. Seventy-four per cent of the computer-based students performed better than the best student in the conventional class. Further, the mean errors for the computer-based class was 6.0, while the mean errors for the conventionally taught class was 15.7.

The automatic generation branching program for individualized remedial lessons was successfully introduced during this quarter. Further refinements are being added. Progress is also being made in the work on disk-generated audio.

TABLE 19

Common Portion of Final Examination of the First Quarter

December, 1968

Total possible errors - 104			
Computer-based class		Conventional class	
Errors	Students	Errors	Students
2	1		
3	2		
4	4		
$5\frac{1}{2}$	2		
6	1		
7	1		
$7\frac{1}{2}$	2		
$8\frac{1}{2}$	1		
11	1	11	1
$11\frac{1}{2}$	1	12	1
		13	1
		15	2
$15\frac{1}{2}$	1		
16	1		
$16\frac{1}{2}$	1		
		17	1
		$17\frac{1}{2}$	1
		19	1
		$21\frac{1}{2}$	1
		22	1
		$24\frac{1}{2}$	1

Total errors	114	Total errors	172.5
Total students	19	Total students	11
Mean errors	6.0	Mean errors	15.7

E. Computer-assisted Instruction in Programming: AID Project

1. The Instructional System

The major effort of the past three months was the design of a computer-assisted instruction system for teaching programming languages. One of the first programming languages to be taught using this system will be AID.[4] The immediate goal is to develop a self-contained course in AID programming, and the secondary goal is to produce an instructional system which will be equally well suited to teaching any programming language, such as BASIC, FORTRAN, ALGOL, or APL.

The curriculum for the AID course is completely outlined and several lessons have been written and coded, but extensive lesson writing has been purposely delayed until the programs for the instructional system are completely written and debugged.

The instructional system will exist in two forms. First, an interim program will operate a single student station and will be used for preliminary testing of the instructional system and the AID curriculum. The final program will be a time-sharing system that will operate 20 student stations simultaneously.

The interim program is about 90 per cent complete and will be operational by the end of January.

Student control of course. The instructional system was designed with the view that a course in programming should be generally aimed at relatively mature students, high school or college age students capable of, and interested in, making decisions about the course of study. For this reason the major part of the system will be designed to allow the student as much control over the sequence of lessons and problems as is feasible. ("Feasible" is used here to mean "feasible from a programmer's point of view." Practical considerations, such as response time may override other considerations in some instances.) Thus, in the lesson strand (core curriculum), the student will be allowed to skip from lesson to lesson in any order, and to skip any problems within a lesson

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[4]Algebraic Interpretive Dialogue is an interactive programming language based on JOSS and implemented by Digital Equipment Corporation for PDP computers. Both the language and the course were described in some detail in previous progress reports.

in much the same way that he might read a textbook, skipping certain chapters, skimming others, and studying some in great detail. The student may, of course, be advised and guided in these decisions. For example, in the AID course there will be lessons which are self-tests whose primary purpose will be to provide the student with an evaluation of his progress and to offer advice based on his test score.

The lesson strand presentation will be essentially linear, much as that of a textbook, with the assumption that most students will begin with Lesson 1 and continue straightforwardly through the sequence. Each problem will be displayed in turn and the student's response will be immediately evaluated; reinforcement will be messages such as "Very good," or "Wrong. Try again." A correct response will branch the student to the next problem in sequence, but the system will wait indefinitely for a student who makes a sequence of incorrect responses. (Of course, the student may skip a problem at any time by using a simple student "control command.") For each problem, the curriculum writer will supply a hint which will be available to the student upon demand. If the writer has failed to supply a hint, the default condition in the system will transmit a message such as "No hint was written for this problem."

Thus, the lesson strand which includes self-tests could serve as a complete course for highly motivated students; for example, the engineer who wishes to learn as quickly and efficiently as possible as much of the algebraic programming language as needed to do a particular job.

Teacher control of course. In an organized course, for example, in a high school or training school, it is not always desirable to have the student in complete control. A need for external evaluation of student progress exists; grades must be given, concrete goals must be imposed on students who are not self-motivated, etc. Homework assignments and tests are the two most commonly used methods for evaluating individual students. In order to provide the teacher with such tools for evaluation, the system will include exercise strands and a test strand in addition to the lesson strand. Both exercise and test strands are tools to be controlled by the teacher, in contrast to the lesson strand which is a tool to be controlled by the student. Tests, for example, can be taken only at certain times decided by the teacher, and in the test strand, unlike the teaching strand, the student will not be immediately informed of the evaluation of his response. Rather, such information will be collected and later released to the teacher. Within a test, the student will be allowed to skip items and return to them later during the same period; he also will be allowed to delete responses and enter replacements, again with the restriction that it be during the same period. Furthermore, since tests in programming courses are ordinarily "open-book" tests, the student will be allowed to set the test aside, i.e., to branch out of the test strand, while he looks at any lesson material and then later returns to the test.

The exercise strands (in the AID course there will be two exercise strands, one for homework assignments and one for extra-credit problems) will also be controlled by the teacher, at least to the extent that individual lessons will be available to the student only as decreed by the teacher, thus allowing him to enforce a schedule for the submission of outside work. There will be more student interaction in the exercise strands than in the test strand, however, since the student will be immediately informed of the evaluation of his responses. Results of the evaluation will also be stored and delivered to the teacher later.

The teacher (if he desires) may allow the student to control tests and exercises; that is, the teacher may make all tests and exercises available at any time.

In summary, the teaching course will consist of several strands which are logically (but, it is hoped, not contextually) independent. The strands will be of three types: lessons, tests, and exercises. The lesson strands will be almost entirely under the control of the student and will supply him with an immediate evaluation of his responses; in the first version of the AID course there will be only one lesson strand although it is conceivable that several lesson strands might be desirable for other courses. For instance, in a course in PL/1, it might be best to have one strand of introductory lessons in the use of PL/1, a second strand for the engineering applications of PL/1, and a third for the business applications. The second kind of strand, the test strand, will be largely controlled by the teacher and will not give feedback to the student. The third kind of strand, the exercise strand, is a combination of the first two kinds; both the student and the teacher receive evaluation, but the lessons are available only when requested by the teacher.

Provision for related curricula. In order to make such a teaching system applicable to a variety of programming languages, there are a number of practical decisions which must be made by the curriculum designer since the requirements will vary from one course to the next and cannot be made in advance of knowledge of the specific programming language to be taught. These decisions include such matters as the allowable maximum length of the student response. In some cases, such as in the AID course, it is desirable to limit student responses to one line of print since AID itself does so, whereas it would be difficult to teach a freely formatted and cumbersome language such as LISP with this kind of restriction. Other decisions which should be left to the curriculum designer include specification of the character used to erase the preceding single character, specification of the "erase-the-last-line" character and specification of the "erase-the-entire-response" character. The character which will be used by the student to signal the end of his answer should also be decided by the curriculum writer. Whether it is feasible to leave all of these decisions to the writer is now being considered.

The teaching system should also be flexible enough to allow for the addition of new procedures for analyzing student responses. There will be standard analysis routines available to all writers, but it is impossible to anticipate the needs for a course in a programming language which has not yet been invented. The standard analysis routines will include routines applicable to multiple-choice problems with a single correct answer, multiple-choice problems with several correct answers, and simple constructed response problems for which the correct response must be an exact match with the coded standard. There will also be routines which will do simple syntactic analyses, such as determining whether a given string of characters is an integer, or a non-negative integer, or a real number in scientific notation. One routine will check for numeric equivalence within specified tolerances, another will check for the use of specified keywords, while still another will determine whether a specified keyword was not used.

2. Implementation

The detailed specifications and development of analysis routines have been a large part of the work of the past two months, and will continue to be a major effort in the near future since the heart of any system of computer-assisted instruction lies in such routines. The procedures for analyzing student responses must be reliable, fast, and discriminatory. The need for reliability needs no justification. The justification for requiring speed is that the system response time, which is so critical to the success of computer-assisted instruction, is largely dependent upon the time taken by the analysis procedures. Although it is probable that older students are more tolerant of delays than, say, elementary school children, (and it may even be argued that students of programming might as well learn early to tolerate the idiosyncracies of computers) it is felt that response times of 10 seconds or more are unacceptable.

Analysis procedures should be discriminatory in the sense that they distinguish, insofar as is practical, not only between correct and incorrect responses, but also between different kinds of incorrect responses. It is only in this way that pertinent diagnostic messages can be given to students who respond incorrectly. Since there is evidence to show that most incorrect responses fall into a very small number of classes (regardless of subject matter), most analysis procedures need discriminate between only two, or perhaps three, kinds of incorrect responses in order to be effective.

A preliminary version of the coding language, which had to be simple to learn and use and had to allow the coder or curriculum writer to be brief without denying him any of the flexibility inherent in the teaching system, was developed. Several lessons were coded in the preliminary coding language and specifications for the final coding language were completed.

The teaching system, in the final version, will consist of the teaching strands mentioned above, including the routines for displaying problem text and receiving student responses, the analysis procedures, the action procedures (i.e., the routines for sending diagnostic messages to the students, giving hints, etc.), the routines for interpreting code written in the coding language, and a supervisor program to allow student-controlled branching between strands. There will also be proctor routines to allow for teacher control of certain strands, a time-sharing monitor to allow simultaneous use of the system by many users, and routines for data collection.

F. Computer-assisted Instruction in Programming: SIMPER and LOGO Project

The course at Woodrow Wilson High School is scheduled to begin in February. Of the 160 students who registered for the first offering, only 90 can be accommodated at this time. The 90 students will be divided into six classes with 15 students in each class.

Twenty teletypes, including five spares, were delivered to the school, and the electrical work necessary to make connections to the PDP-8 when it arrives was started.

Phyllis Sears, director of the project, visited classes several times before beginning work on curriculum material. She also conducted an 8-hour session workshop to acquaint teachers with SIMPER and LOGO.

The first 20 SIMPER lessons were coded and debugged. Corresponding homework lessons and tests were written, as were the first drafts for the teacher's and student's manuals. The driver for the curriculum lessons was written and almost completely debugged. Further debugging will continue and refinements are being added.

G. Stanford PDP-1/PDP-10 System

1. Hardware

New remote teletype clusters were installed at both Tennessee A. and I. University and in the Ravenswood School District, and another was ordered for San Francisco. These systems are operated by the same techniques as those used at the Kentucky and Mississippi installations. In addition to the teletype cluster controlled by its own PDP-8 at Ravenswood, several more terminals were connected directly by telephone line to the Stanford laboratory. At the same time, the PDP-8 at Stanford was expanded to handle the increased load of local terminals. This combined configuration for Ravenswood proved to be the most economical in terms of both computer equipment and telephone-line charges.

In Washington, D. C., the third remote installation, a relatively small number of terminals were required, and the usual alternatives of a remote PDP-8 or individual low-speed phone lines for each terminal proved to be too expensive on a per terminal basis. Therefore, a single high-grade line was leased for the other remote clusters. In place of the PDP-8, hardware multiplexing equipment was installed at both ends of the line, as if it were several local teletypes. A number of multiplexing systems were investigated; the unit selected is made by Collins Radio. The multiplex units can be expanded easily in the future to handle several more terminals over the same line. After several weeks of routine daily operation, this technique has proved to be a reliable, economical solution for small clusters.

Two Ampex memories are now operational on the PDP-10, giving a total of 64K words (plus 16K in the lower Fabritek memory). All six memory units were delivered by Ampex, and are in various stages of interfacing and check-out. The first two units are connected to the PDP-10, the PDP-1, and 2314 disk channel, the high-speed communications line controller, and the digitized audio unit.

The data channel for the IBM 2314 disk is completed and has been in service for most of this quarter. The second disk channel is also completed and in final debugging stages. The second 2314 disk file was delivered in mid-December and is undergoing on-site tests by IBM field engineering.

The high-speed data line interface units and the memory control unit are completed and operational. These units, controlled by the PDP-10, operate the high-speed lines to the remote PDP-8's. This arrangement replaces the configuration of DEC Model 637 interface units on the Stanford PDP-8, allowing its expansion to handle more local terminals. The 637 units thus released are being used in the new remote PDP-8 installations.

2. Software and Operations

The time-sharing system distributed by DEC for the PDP-10 was modified to run on our machine. These modifications were dictated by the fact that virtually none of the standard PDP-10 input/output devices exists in our configuration. In particular, code to operate the 2314 disk had to be created, and a software linkage was set up to allow the Philco display consoles on the PDP-1 to appear as time-sharing "teletype" terminals on the PDP-10.

While the modified DEC system allowed programs to be prepared, assembled, and debugged, it did not furnish many of the facilities required by the instructional programs which were to be run on the PDP-10. In parallel to the above work, an independent system was developed which included the features required by the laboratory and provided service for specialized equipment, such as the high-speed data line interface and the digitized audio unit. After the two systems were running satisfactorily, they were merged into a single operating system that provided the features of both. While this interim system is large and somewhat inefficient, it does provide the necessary framework to proceed with the development of the arithmetic drill program.

Much of the work on the drill program was done in parallel, and in close cooperation, with the systems project. As the only full-scale program on the machine, the drill program is used as the major tool in debugging the time-sharing system and the hardware.

During this period it was also necessary to make a number of changes in the PDP-1 time-sharing system and the PDP-8 program. Users at the Philco consoles can now run programs on either the PDP-1 or the PDP-10, or on both simultaneously. A rather complex software network was set up which allows both the PDP-1 and PDP-10 access to all local teletypes controlled by the Stanford PDP-8. For use during the transition period, one of the new high-speed line units operating in high-priority interrupt mode was installed directly on the PDP-1. This provides for a flexible remote-line configuration, but involves considerable CPU overhead when in use.

Every effort is being made to maintain operational status on all systems during the daytime hours through this period of transition to the PDP-10. Although there have been periods of unavoidable and sometimes unpredictable down-time, it is hoped that these can be held to a minimum. Considering the sheer volume and complexity of new and unfamiliar hardware and programming, the project has proceeded with a remarkable lack of major troubles.

II. Activities Planned for the Next Reporting Period

A. Drill-and-practice Mathematics Program

Work will continue to extend the strand program through grades 7 and 8. Special strands, problem-solving, and algebra will receive considerable emphasis, particularly with respect to establishing a reasonable and efficient set of commands for students to use.

The operation of the drill-and-practice program will be shifted from the PDP-1 to the PDP-10 computer. New teacher reports will be generated. A sign-off feature will be added to the program that will permit students who must leave during a lesson to sign off and return at a later time to complete their lesson.

The blocks for Tennessee A. and I. will be revised as needed if format problems occur.

The data analysis group will decide upon the exact summary information to be compiled from the strand data. Models will be developed to aid in determining the adequacy of the ordering of equivalence classes.

Work will begin on development of an algebra program which involves some of the techniques presently used in the logic and algebra program. The new program, however, will emphasize problem solution rather than proofs and will be written for eighth and ninth graders.

Classification of all problems presented during the 1967-68 year according to the strand and equivalence class defined in the new strand program will continue.

B. Drill-and-practice Reading Program

The curriculum prepared through Strand 4 will be processed for use on the PDP-10, and efforts will be made to complete the materials for Strand 5. The recording of the reading dictionary will be completed. An instructional manual will be compiled to acquaint the Ravenswood teachers with the operations and materials unique to the reading drill-and-practice program.

C. Logic and Algebra Program

1. The First-year Program

As soon as the drill driver becomes operational, the curriculum will be debugged. The few remaining lessons will also be coded.

2. The Second-year Program

Lesson writing and coding. Work will continue on the teacher's manual and the writing and coding of the remaining lessons. Observation of student progress will continue at Walter Hays Elementary School.

Students ready for the second-year program should be ready to start in the next quarter.

3. Programming

Programming of a new version of the logic program that includes computer generated dialogue will begin in mid-February. These programs will utilize logic curricula compatible with the PDP-10 logic/algebra coding format, and should be completed by mid-July.

D. Second-year Russian Program

Translations will be added to the optional pronunciation drills and dictation. Students will be required to write English translations for sentences read in Russian.

Homework assignments will include required daily reading of a page from a Chekov short story. If students have difficulty understanding some passages, they may ask the computer for assistance the following day.

Discussion of stories and required written translations of sentences and paragraphs from required home reading will be added to the Friday schedule of quizzes and pronunciation sessions.

E. Computer-assisted Instruction in Programming: AID Project

In the next three months the teaching system will be developed sufficiently to allow a small-scale pilot study of the lesson strand. Curriculum material for the introductory section of the lesson strand of the AID course will be developed and testing with students will begin. The results of the pilot study should lead to meaningful revisions of both the teaching system and the curriculum material.

F. Computer-assisted Instruction in Programming: SIMPER and LOGO

Revision of the first 20 lessons of curriculum material, based on teacher's comments, will be made during the next quarter. The writing of SIMPER lessons will be completed, and the first few LOGO lessons will be designed.

Delivery of the PDP-8 is expected, and on February 3, the first class will meet.

Programs for inaction between LOGO and the teaching program, plus programs for providing teacher reports on homework, tests, and extra-credit problems will be written. Edit features will be added to the version of LOGO now available.

G. Stanford PDP-1/PDP-10 System

During the first few weeks of the next quarter, the second 2314 disk file with its channel hardware and the remaining units of Ampex core memory should become operational. The IBM tape drives, the teletype "Inktronic" high-speed printer, and a PDP-8/I should also be delivered early in the period. The PDP-8/I, the new integrated-circuit version of the PDP-8, will be used in the remote terminal cluster in San Francisco. The tape drives will be attached to the existing disk channel, but a new hardware interface must be designed and built for the Inktronic printer. The remaining 1301 disk file and the file control unit will be released to IBM after conversion of the PDP-1 system to use the 2314 files through the PDP-10. Debugging activity should be completed on the digitized audio system, and initial design efforts for interfacing the PDP-8 and the Philco displays to the PDP-10 will be undertaken.

The hardware work outlined above, while still considerable, does not compare with the high level of hardware activity completed during the previous quarter, and more attention will be focused on PDP-10 software development. Major projects will include refining versions of the time-sharing system, establishing new routines to handle the additional hardware, and compiling a variety of utility service packages.

III. Dissemination

A. Publications

Atkinson, R. C. Degree of priming in the retrieval of author's names from long-term memory. Psychonomic Science, 1968, 12, 399-400 (with R. H. Hopkins).

Atkinson, R. C. Short-term memory as a function of rehearsal procedures. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 730-736 (with J. W. Brelsford, Jr.).

Atkinson, R. C. Applications of multiprocess models for memory to continuous recognition tasks. Technical Report 138, December 18, 1968, Stanford University, Institute for Mathematical Studies in the Social Sciences (with R. D. Fruend and G. R. Loftus).

Atkinson, R. C. Information delay in human learning. Technical Report 139, December 18, 1968, Stanford University, Institute for Mathematical Studies in the Social Sciences.

Suppes, P. The desirability of formalization in science. J. of Philosophy, 1968, 65, 651-664.

B. Lectures

Atkinson, R. C. Computer-assisted learning in action. Lecture presented to Symposium on Computer-assisted Learning at the National Academy of Sciences, Autumn Meeting, California Institute of Technology, Pasadena, October 28, 1968.

Atkinson, R. C. Participant at Conference on Instructional Strategies Appropriate to Computer-assisted Instruction, sponsored by the Office of Naval Research in Washington, D. C., (Discussion on Instructional Strategies), October 29-30, 1968.

Jerman, M. Computer-assisted instruction, the Stanford CAI program. Lecture presented to the staff of Ravenswood School District, East Palo Alto, California, October 7, 1968.

Jerman, M. Computer-assisted instruction in elementary mathematics. A lecture given to the Cincinnati Board of Education and staff, Cincinnati, Ohio, October 11, 1968.

Jerman, M. Workshop in computer-assisted instruction. A series of lectures to the staff of Tennessee A. and I. State University staff and visitors, Nashville, Tennessee, October 17-18, 1968.

Jerman, M. Workshop on the Stanford Drill-and-practice CAI program for the staff of Kendall School for the Deaf and visitors from the office of H.E.W., Washington, D.C., November 7, 1968.

Jerman, M. Workshop in CAI for New York City teachers. A series of workshop sessions, New York, December 6-14, 1968.

Kanz, G. Workshops in CAI for the Ravenswood City School District teachers as follows:

October 7, 1968	Belle Haven, Kavanaugh, Costano
October 8	Brentwood, Runnymede
October 9	Flood, Willow, O'Connor
October 15	Runnymede, Brentwood
October 16	Willow, Flood, O'Connor
October 21	Kavanaugh, Belle Haven, Costano

October 22	Runnymede, Brentwood
October 23	O'Connor, Flood, Willow
October 28	Costano, Belle Haven, Kavanaugh

Suppes, P. Computer-assisted instruction in elementary mathematics. Lecture presented at Northwest Mathematics Conference, Pacific Lutheran University, Tacoma, Washington. October 4, 1968.

Suppes, P. On teaching the algorithms of arithmetic. Lecture presented at Northwest Mathematics Conference, Pacific Lutheran University, Tacoma, Washington, October 5, 1968.

Suppes, P. Intuitive geometry of two and three dimensions. Lecture presented at National Council of Teachers of Mathematics meeting at Corpus Christi, Texas, October 17, 1968.

Suppes, P. Computer-assisted instruction in elementary mathematics. Lecture presented at National Council of Teachers of Mathematics meeting at Corpus Christi, Texas, October 18, 1968.

Suppes, P. Four programs in computer-assisted instruction. Lecture presented at Conference on Computer-assisted Instruction, Testing and Guidance, sponsored by Social Science Research Council and College Entrance Examination Board, The University of Texas, Austin, Texas, October 22, 1968.

Suppes, P. The Stanford program in computer-assisted instruction. Invited lecture presented at National Council of Teachers of Mathematics meeting at Boston, Massachusetts, November 15, 1968.

Suppes, P. Computer-assisted instruction. Invited lecture presented at the Fall Symposium of the Digital Equipment Computer Users Society, San Francisco, California, December 12, 1968.

Suppes, P. Computer technology and the science of curriculum. Invited lecture presented at the annual meeting of the American Association for the Advancement of Science at Dallas, Texas, December 27, 1968.

Suppes, P. The desirability of formalization in science. Invited lecture at annual meeting of the American Philosophical Association, Washington, D. C., December 29, 1968.