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ABSTRACT

Between April 1, 1968 and June 30, 1968, the Stanford Program in Computer Assisted Instruction was engaged in eight major activities. Graphs show the progress of the Brentwood Mathematics Program's 73 on-line students and the four-state Drill-and-practice Mathematics Program's 3,823 students. The Brentwood Reading Program evidenced that the curriculum accommodated individual differences and that student terminal behavior did not interfere with learning. Extensive testing data show some statistical improvement. Form-class study continues to determine if there is some evidence for the psychological reality of degrees of grammaticalness. Data from the Logic and Algebra Program indicates that students should begin with algebraic rules of inference. The Dial-a-drill Program is testing branching criteria and the relative difficulty of fraction problems. The success of the Elementary Russian Program promises to be statistically significant. No data are available for the Spelling Program. Adaptations for the new PDP-1 System are in process. Coding changes, curriculum revisions and supporting materials are itemized. The activities planned for the next reporting period include all the above except the Brentwood Mathematics Program and the Dial-a-drill Program. (MM)

PROGRESS REPORT

STANFORD PROGRAM IN COMPUTER-ASSISTED INSTRUCTION

for the period

APRIL 1, 1968 to JUNE 30, 1968

STANFORD SUBCONTRACT UNDER OFFICE OF EDUCATION
GRANT NO. OEG-9-8-685083-0041
WITH RAVENSWOOD CITY SCHOOL DISTRICT
Principal Investigator: Patrick Suppes

NATIONAL SCIENCE FOUNDATION GRANT NSFG-18709
Principal Investigator: Patrick Suppes

STANFORD SUBCONTRACT UNDER OFFICE OF EDUCATION
GRANT NO. OEG-3-7-704721-5096
WITH McCOMB, MISSISSIPPI PUBLIC SCHOOLS
Principal Investigator: Patrick Suppes

STANFORD SUBCONTRACT UNDER OFFICE OF EDUCATION
GRANT NO. OEG-0-8-056480-2921
WITH EKEDC (PAINTSVILLE, KENTUCKY BOARD OF EDUCATION)
Principal Investigator: Patrick Suppes

OFFICE OF EDUCATION CONTRACT OEC-0-8-001209-1806
Principal Investigator: Joseph Van Campen

INSTITUTE FOR MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES
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STANFORD, CALIFORNIA

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A. Brentwood Mathematics Program

1. Student Use of Laboratory and Analysis of Results

Enrollment. Of the 79 students in the program at the end of the quarter, 2 enrolled during the quarter and joined the other regular 67 on-line students. Another 6 students were taken off-line completely and given all their mathematics work in the classroom, because their progress on-line was negligible, their behavior was disruptive for the entire group, and their attitudes toward working on the machines were negative and evidenced a great deal of frustration. Four other children whose behavior had been disruptive were taken off-line until they showed a desire to return to their programmed lessons and to work without disturbing other children. Thus, 69 children worked on-line for the entire quarter and 4 children worked on-line most of that time.

Change in children's schedules. Owing to the slow machine-response time, which developed during the preceding quarter, a decision was made to change the children's scheduled time on-line. The only way to decrease the response time was to have fewer students on-line at a given time. The following changes, then, were put into effect: (a) Group 1 was divided in half with sub-groups using the machines on alternate days; (b) Groups 2 and 3 (small groups originally) maintained their original schedule; (c) Group 4 was divided in two with each sub-group using the machines for one-half of the period; and (d) Group 5 was divided in two, the period lengthened by five minutes, and each sub-group used the machines for one-half of the period. In the three groups where scheduling changes were made, the machine-response time improved noticeably. The children were able to complete more lessons in a period than before (in many cases the children completed twice as many lessons), restlessness diminished with correspondingly more attention devoted to lessons, and discipline problems decreased dramatically. Remarks such as, "This machine is too slow" were rarely heard, where before such remarks had been common.

Student progress. Table 1 shows the number of students who finished a book during a particular week.

At the end of the year, the spread of the children was from Book 14 through Book 49, which one child finished on the last day of school.

TABLE 1

Number of Children Completing a Book, Brentwood Mathematics

April - June, 1968

Week of:	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
April 1-5						2	2		1	1	4		3			1			2																					
April 8-12			Spring Vacation																																					
April 15-19	1	1	1		2	2	5	6	4	2	2	3	5	3	1	6		1	1	2	3	1	1	1		2	2													
April 22-26				3	2	2	2	6	5	1	1	4	1	6	4	1	6	1	1	1		1	3	1	1	1		2	2											
April 29- May 3			1					2	2	1	1	1	1	1		2		4			1	1		2	1		1			2										
May 6-10		1			1	2	1	1	6	2	2		3	1	5	2	1	1	2		1	1	1		2	3		1			2									
May 13-17			1	1	2		3	3	3	4	2	1	1	1	1	3	2	5	2	3		1	1	1	1		3		1	1		2	2							
May 20-24				1	1	2	1		1	3	3	3		3		3	1	1	4	2	2	1	1	1	1	1		2	2		1	1	1	2	2					
May 27-31				1		2	1	2	3	3	4	2	2	1	1	1	3	1	1	4	3			1		1	1	1		2				1	1	2	2			
June 3-7						1	2	2		2	4	5	4	1	3				3		4	2	2		1		1	1	1		2	1				1	1	2	2	1

Lesson failures. By the end of the year, only the first 13 books were completed by every child who was still working on-line. The lesson failures for Books 1-10 were summarized in reports for the two preceding quarters Lesson failures for Books 11-13 are summarized in Table 2.

Student achievement Tables 1 and 2 give a general idea of the rate of progress through the material and the kinds of lessons with which some children had difficulty. Another indicator of pupil progress was the proportion of problems to which students responded correctly. Table 3 shows the number of children whose achievement for the week fell within the indicated range of percentage correct.

Classroom activities. During this quarter, the principal classroom emphasis was on graphing. In order to make the graphs, the children had to use many of the techniques and skills learned throughout the year. For example, before making a graph about a particular topic, it might be necessary to make various measurements, make a survey, extract information from stories or other written material, use addition or subtraction, or decide on appropriate units or an appropriate scale on which to represent the information being graphed.

Other activities included some work with compasses and straightedges in making simple geometric constructions; reading and solving story problems, including the writing of mathematical sentences; work with identifying and completing patterns; and continued practice with addition and subtraction,

Testing. During the last three weeks of school, the Stanford Achievement Test, Primary II Battery, Form W, was administered to all children in the program, as well as to all the children in the control group, the second-grade classes at Kavanaugh School. Analyses of these results and comparisons between the two groups will be made during the summer.

2, Coding

The major coding change during the last quarter was the coding of typing problems in text rather than graphics. Prior to Book 42, the number typed by a student was processed for a match, and its corresponding graphic numeral was displayed on the CRT. In this way each number was processed separately; for example, 12 was processed twice before the final processing to determine whether the answer was correct. In typing text, the number typed instantly appeared on the CRT and was not processed until the student had completed his response; thus, 12 in text was processed only one time rather than three, as it would have been in graphics. This change effected shorter code and faster

TABLE 2

Lessons Failed in Books 11-13, Brentwood Mathematics

Book	Lesson	Description	Number of Failures
11	B	subtraction from 11, 12, 13	4
	D	sums to 11, 12 13, three addends	22
	E	subtraction from 11, 12 13	11
	F	review equal sets	2
	G	balancing union of sets equations	6
	H	subtraction from 11, 12, 13	3
	J	counting by twos through 18	3
	K	review half	3
	M	subtraction from 11, 12, 13	3
	N	counting by twos	1
	R	names of multiples of ten	1
	S	balancing union of sets equations	3
	T	relating addition and subtraction, facts to 10	1
	V	review union of two or three sets	5
12	A	subtraction from 12 and 13	27
	B	review counting money less than 20¢	6
	C	numeral recognition through 99	1
	D	recognition of number of dots in a pattern	25
	E	subtraction from 11, 12, 13	18
	F	introduction to supplying $=$ or $\neq$ with sets	4
	G	introduce $\neq$ with numerals	25
	H	$=$ or $\neq$ with numerals	6
	K	rotation of similar figures	2
	L	subtraction from 11	8

TABLE 2 (cont'd)

Book	Lesson	Description	Number of Failures
	N	union of sets	9
	R	subtraction from 12	9
	T	subtraction from 13	2
	U	review of open and closed figures	14
	W	subtraction from 11, 12, 13	22
13	B	n + 10 where $2 \leq n \leq 4$	5
	C	n + 10	2
	D	counting from n, commutativity	12
	F	review one half	9
	G	review = and $\neq$	9
	H	review more, less, the same	28
	I	review equal sets	3
	J	counting from n for sums to 13	5
	M	oral drill on numeral recognition	4
	N	readiness for supplying missing addend	18
	R	subtraction from 11, 12, 13, vertical format	50
	S	review union of sets	6
	T	mixed addition and subtraction oral drill	27
	V	review similar figures	6
	W	review counting by twos	3

TABLE 3

Distribution of Children According to Percentage Correct for the Week,
Brentwood Mathematics
(April - June, 1968)

Week of:	60 and below	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100
April 1-5	1		3	2	6	7	17	12	4
April 8-12	Spring Vacation								
April 15-19	1	2	4	4	5	15	24	18	3
April 22-26				4	5	16	28	14	4
April 29-May 3	3		5	3	8	11	16	15	6
May 6 10	2	4	1	6	4	13	21	18	4
May 13-17	1		2	6	9	17	20	13	5
May 20-24	3		4	2	6	11	25	16	1
May 27-31	3	1		4	8	13	17	23	1
June 3-7	2		3	2	11	14	22	15	2

execution time. The code had less to check and was, therefore, shorter; any given answer was processed fewer times and was, therefore, more rapidly completed. It is estimated that a given set of responses in text was processed 35 per cent faster than the same set of responses in graphics.

The factors affecting response time were so complex and elusive that the full significance of text typing for execution time cannot be conjectured until used by students under normal running conditions. The projected 35 per cent savings is reasonable simply because the typing problems are processed fewer times, but whether the processing itself will be faster is moot. The effect of text typing upon disk space was, however, readily discernible. The 13 course segments thus far assembled since the change to text typing (Book 42) were much shorter than those preceding the change. The average length of these segments was 109 sectors (units of space on the disks). The previous average was 152 sectors. This reduction was almost wholly the result of the changeover to text typing, though light-pen processing was also somewhat shortened since Book 42 (see fn data, under Functions, below). It should be noted that this reduction was based on a comparison between segments (a segment is half a book) coded primarily with subroutines (post Book 24). The savings over the earlier segments without subroutines was far more pronounced, as indicated in Table 4 (cf., Quarterly Report, October-December, 1967).

Subroutines. The problem 2 + 3 = __ was processed in much the same way as was 4 + 5 = __. The differences were few: the correct-answer definition; the display of the answer in the giveaway routine (when the student made no response or too many incorrect ones); the response identification number, et al. But 35 or more commands were identical. Initially, these 35 commands were repeated for each problem, since there was no apparent way to generalize the specific differences among similar problems. Since then, several functions have been written that allow these variables to be coded for counters and buffers, which were themselves defined individually with the presentation of each problem. The result was that similar problems within a segment can be processed by the same block of code. Any piece of code branched to from more than one point in the course and used for more than one purpose, such as the processing of several distinct problems, was called a subroutine. Thus, almost all responses were partially, if not wholly, processed with code shared by more than one problem. All the response processing macros (commonly used programs) used by the

TABLE 4

Comparison of Segment Length

Average number of sectors per problem	
Presubroutine	1.9
Subroutines before Book 42	1.22
Subroutines after Book 41	.82
Average course segment length (in sectors)	
Presubroutine	215
Subroutines before Book 42	152
Subroutines after Book 41	109
Average number of statements to process typing problem	
Presubroutine	85
Subroutines before Book 42	43
Subroutines after Book 41	16.5
Average number of statements to process light-pen problem	
Presubroutine	37.0
Subroutines before Book 42	14.0
Subroutines after Book 41	11.2

mathematics coders were written in the form of subroutines. This extensive use of subroutines would not be feasible without functions.

Functions. Coursewriter II (CWII) has an open command called *Fn* (for function) which allows the programmer virtually to define his own CWII commands. The mathematics group used eight functions.

Fn Data. The most recently defined function, *fn data*, generates the response identification number associated with each problem. The initial characters of the response ID are loaded into a register at the start of each lesson. *Fn data*, called with each problem, adds a sequence number to the contents of the register, and records the result as the unique identifier of the problem. The primary purpose of *fn data* is to reduce the possibility for error in coding response ID. Since the ID is coded only once per lesson (i.e., 10 problems), the task of checking is decimated.

Fn data also effected a disk-space savings for light-pen problems. Since the response ID had to be unique, the commands associated with it could not previously be put into the light-pen subroutines. With the use of *fn data*, these commands were put in the subroutines and thus were not repeated for every problem.

Fn Ans. Function Ans(wer) is an alternative to the CWII answer set commands: CA, WA, AA. With *fn ans*, the text or light-pen coordinates of an answer match can be defined as the contents of a buffer or counter(s). This function is used in all light-pen subroutines, in that the correct-answer definition is utterly variable. Without *fn ans*, light-pen subroutines would be impractical. Since *fn ans* supercedes a major command (those that determine course-flow logic), the coder must indicate in what way the logic will be updated (i.e., what subsequent commands will be executed under what conditions). The options open to the coder are not confined to those of the answer sets, but the *fn ans* command logically could act like *any* of the major commands. In addition, the logic could be updated differently, depending on whether the response is a match or a mismatch with the definition of the fn ans. No other CWII command can do this. For example, a CWII answer set command, say CA, updates the logic as a CA MATCH or a CA MISMATCH. But fn ans *can* act like a CA MISMATCH *if it is a match* and a WA MATCH *if it is a mismatch*--or any other combination of logic conditions the coder chooses.

Fn Dg. This is an expansion of the CWII DG (display graphic) command. Fn dg allows the placement coordinates and the graphic numbers to be expressed as the contents of counters. Like fn ans, these options are essential for subroutines in which a graphic display is a variable (e.g., the placement of the arrow in light-pen giveaway routines). When fn dg is called with only placement values and no indicated graphic to be displayed (whether number or counter), the graphic equivalent of the last typed response, if it is a number, is displayed at the specified position on the CRT. This is how the student can "type" graphic numerals.

Fn Dt. This is parallel to the CWII DT (display text) command, allowing the placement coordinates to be coded as the contents of counters. This function was written specifically for text-typing subroutines.

Fn Edit and Fn Build. These are, in a sense, one function, but they have so many facets that they occupy the core area of two functions. They shall, however, be referred to as one. Fn edit/build manipulates the contents of buffers; however, the options are too extensive and complex to detail. The effect is that buffers can be altered selectively and read so that they are powerful processing tools--as when a student response is stored in a buffer for processing. For example: in a typing problem of 9 + 3 = __, the correct answer is defined as 12. The student, however, can type 12 in many ways that will not match with a simple definition of 12. He could type--and the response buffer would store--1, space, backspace, 2; or 1, backspace, space, 2; or space, backspace, 1, 2; or backspace, space, 12; or space, 1, 2; and on and on. There are several dozen ways to type 12 correctly in which the response buffer would mismatch with a definition of the CA as 12. To code a string of CA's encompassing all these possibilities would be exceedingly inefficient, both in the disk space used and in the execution time necessary to check all the matches. Even then it would be too easy to overlook a legitimate definition. The problem is resolved by deleting all the spaces and backspaces from the response buffer before encountering the CA definition. This can be achieved with the edit function:

Given: B0 = buffer zero, the response buffer.
→ = character for space.
← = character for backspace.
B1 = buffer one, any free buffer.

After the response is made:

LD →←/B1	load space and backspace into B1; these will be the only contents of B1.
FN EDIT/DE/B0/B1	delete from B0 all characters contained in B1.
CA 12/	if 12 was typed with any combination of spaces and backspaces, B0 will contain only the 12 and will thus match with the CA.

Fn Fade. When this command is encountered, the student is signed off at the first subsequent restart point (i.e., the beginning of the next lesson). The proctor has the option of "fading" a student, but her criterion would be temporal (the session is almost over). *Fn Fade* can be coded into the course to "fade" the student on the basis of other criteria relevant to content, such as when the student cannot continue until he is registered off-line for a new course.

Fn Ld. This function simplifies correlating the various scorekeeping/counting tools of CWII by the coder. *Fn Ld* allows the contents of counters, buffers, switches, and registers to be loaded directly into each other. CWII does not allow such options.

3. Data Analysis

Descriptive analysis of group performance on first-grade geometry problems. A detailed examination was made of the mean proportion correct for first response on 48 identification-of-geometric-figures problems. The problems were presented in five lessons (i.e., identification of squares, circles, figures with three corners, triangles, and rectangles). All items were of the probe-response type with either two- or three-response alternatives. The alternatives were arranged in a vertical format; the position of the correct response (top, middle, or bottom) did not affect performance. The proportion correct for the first problem in each lesson was always lower than the mean proportion correct for all problems in that lesson. The problems which required identification of squares and rectangles had a lower proportion correct than those that required identification of circles, figures with three corners, and triangles. Finally, the proportion correct decreased as the similarity between the correct response and an incorrect alternative increased.

These results are presently being used in the analysis of the second-grade geometry curriculum and may be used further as guidelines in the development of learning models for elementary geometry.

B. Brentwood Reading Program

1. Curriculum Preparation

Written lessons. The written lessons for Levels I through VIII were completed. Additional lessons which were inserted in the beginning, middle, and end of Level I provided letter instruction and practice to insure recognition and knowledge of letters before subsequent lessons were attempted by the students. A revised comprehensive section, which could be implemented at any time, was prepared for Level VIII. Supplementary materials and Teacher's Manuals through Level III were made available for classroom use by the Brentwood teachers.

Art work. The accompanying illustrations for the lessons were completed through Level VII and the films were processed through Level VI. The original plates are in the Ventura Hall storage area and are available for appropriate use.

Audio. The master narration tapes for lessons through Level VII received their final editing and were sent to the Brentwood Laboratory where master tapes were completed through Level VI.

2. Coding

All lessons through Level V were completed and thus ready for terminal-room usage. Approximately 50 per cent of Level VI lessons are available for student use with 85 per cent of the debugging and correcting of the remaining lessons completed. The first 10 lessons of Level VII are finished, except for testing with films that could not be completed because of the termination of this phase of the project. The remainder of Level VII is coded entirely and approximately 60 per cent debugged and corrected.

3. Student Use of Terminals

Enrollment and progress. At the close of this spring quarter, 81 first-grade students, plus 7 remedial fourth graders who began in March were enrolled in the program. Table 5 indicates the number of first-grade students working in each lesson from the end of the 26th through the 34th weeks. Student use of the terminals this year exceeded that of last year by 8 weeks and 34 lessons. Figure 1 indicates the distribution of students over the number of lessons completed for this year and last year. Figure 2 shows the number of minutes students spent at terminals and the number of problem types completed. A weekly progress report from October 13, 1967, through June 7, 1968, is shown in Figure 3 for the slowest, the fastest, and an average student. This year's student progress gave further

TABLE 5

Weekly Distribution of First-grade Students in Each Lesson, Brentwood Reading

(April 1 to June 7, 1968)

	Week Number	26	27	28	29	30	31	32	33	34
	Number of Students	79	78	78	79	81	81	80	81	81
Level I	Letter teaching		1			1				
	Lesson 1	1	0	0	1	1	0	0	0	0
	2	1	1	2	0	1	2	0	0	0
	3	1	2	0	2	2	1	0	0	0
	4	0	0	2	1	1	3	3	2	1
	5	3	1	0	1	0	0	2	1	0
	Letter teaching	2	3	0	0	1	0	1	2	2
	6	0	0	3	3	1	1	0	1	0
	7	2	1	2	1	2	2	1	0	1
	8	1	1	1	1	0	1	1	1	2
	9	4	2	3	3	4	1	2	1	2
	10	3	4	2	3	2	2	1	3	2
	11	0	0	2	0	2	2	2	0	1
	12	6	2	2	4	2	4	4	5	2
	13	5	3	1	0	2	1	3	1	4
	Letter teaching	3	1	2	0	1	1	0	2	0
Level II	Lesson 1	3	6	4	5	4	1	1	1	1
	2	0	5	6	4	1	4	3	2	2
	3	2	0	1	4	3	1	3	1	2
	4	1	1	1	2	4	3	0	2	0
	5	3	2	2	1	3	4	5	2	5
	6	1	2	2	1	1	1	1	3	0
	7	1	3	3	5	3	4	4	5	7
	8	0	0	1	0	2	3	2	0	1
	91	2	0	0	1	1	1	2	3	1
	92	5	1	0	0	1	2	4	4	5
	10	0	6	6	5	2	1	0	3	3

TABLE 5 (cont'd)

	Week Number	26	27	28	29	30	31	32	33	34
	Number of Students	79	78	78	79	81	81	80	81	81
Level II	Lesson 11	0	0	1	2	1	1	1	0	1
	12	1	0	0	0	4	1	1	2	0
	13	1	1	1	0	0	2	0	0	2
	14	1	1	0	1	1	2	4	0	0
	15	3	1	1	2	1	1	1	3	1
	16	1	3	1	0	0	1	0	2	1
	17	0	0	2	0	0	0	2	0	2
	18	0	1	1	0	1	0	0	0	1
Level III	Lesson 1	0	0	0	3	2	1	0	2	1
	2	3	1	1	0	1	2	1	1	2
	3	3	0	0	1	0	0	2	0	0
	4	0	3	2	2	3	2	0	2	2
	5	0	2	2	1	0	1	0	0	0
	6	0	0	0	1	0	1	1	0	0
	7	0	0	1	0	1	0	2	0	0
	8	1	0	1	1	1	0	1	1	0
	9	2	1	0	1	1	1	1	3	1
	10	1	1	0	0	0	0	0	1	2
	11	0	1	2	2	1	1	1	0	2
	12	1	1	1	1	2	2	0	1	1
	13	0	1	1	0	1	2	1	1	1
	14	0	0	1	1	0	0	2	0	0
	15	1	0	0	1	1	2	1	3	1
	16	2	1	0	0	1	1	2	1	2
	17	0	0	0	0	0	0	0	0	0
	18	1	2	1	1	0	1	1	1	1
	19	0	0	1	1	0	0	0	2	1

TABLE 5 (cont'd)

		26	27	28	29	30	31	32	33	34
	Week Number	26	27	28	29	30	31	32	33	34
	Number of Students	79	78	78	79	81	81	80	81	81
Level III	Lesson 20	0	1	1	1	2	0	0	0	0
	21	2	0	0	0	0	0	0	0	2
	22	0	0	1	0	0	1	0	0	0
	23	0	0	0	1	0	1	2	0	0
Level IV	Lesson 1	1	2	2	0	1	0	0	2	0
	2	3	0	0	2	0	1	0	0	2
	3	0	1	0	0	2	0	1	0	0
	4	0	3	0	0	0	1	0	1	0
	5	0	0	3	0	0	1	0	0	1
	6	1	0	1	4	0	0	2	1	0
	7		0	0	0	1	0	0	1	0
	8		1	0	0	3	0	0	0	2
	9			1	0	0	3	0	0	0
	10			0	1	0	0	1	0	0
	11					0	1	1	1	0
	12					1	0	2	1	1
	13						1	0	2	1
	14							1	0	1
	15								1	1
	16									1

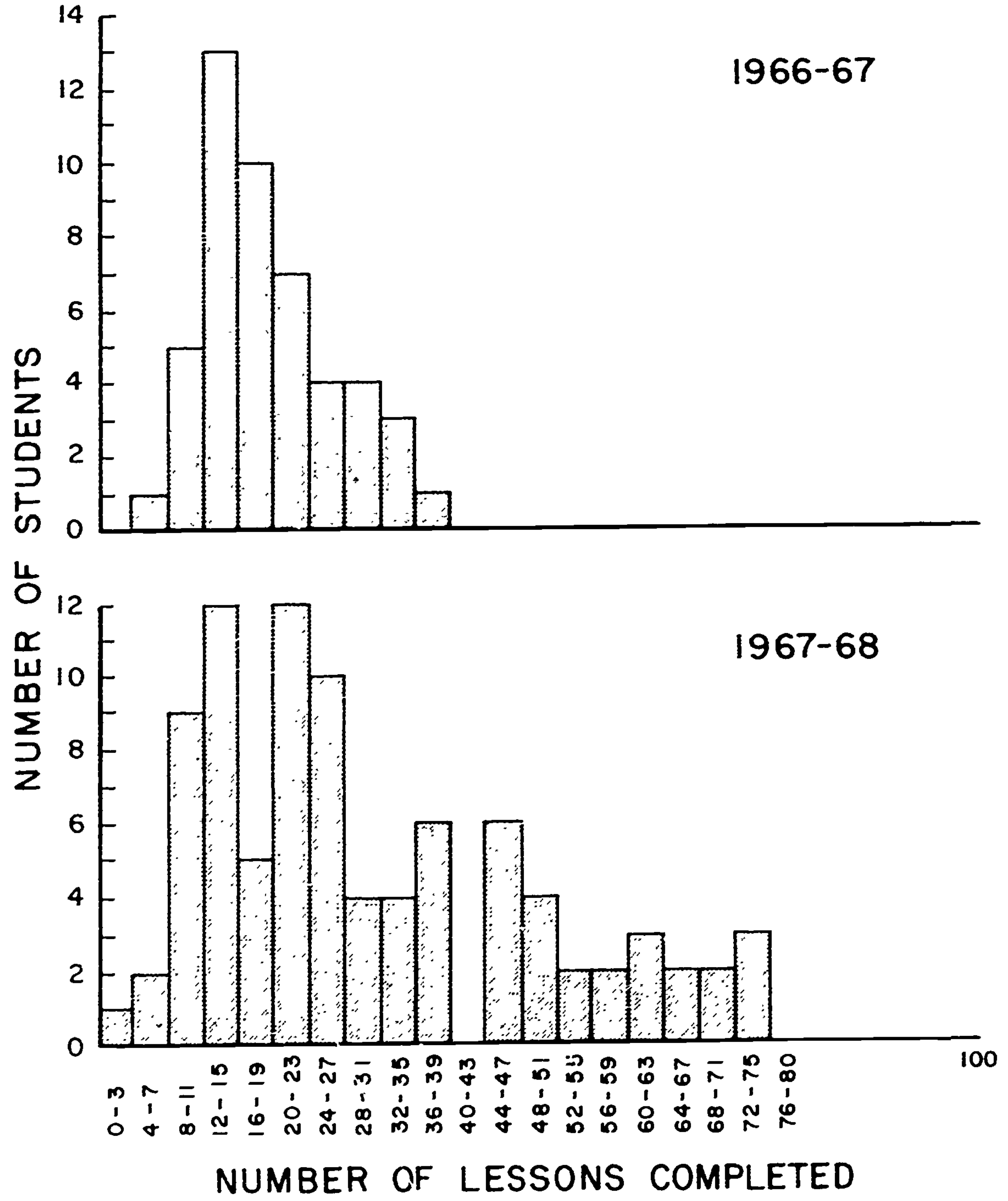

Fig. 1. Distribution of Students Over Lessons (1967-68), Brentwood Reading Curriculum

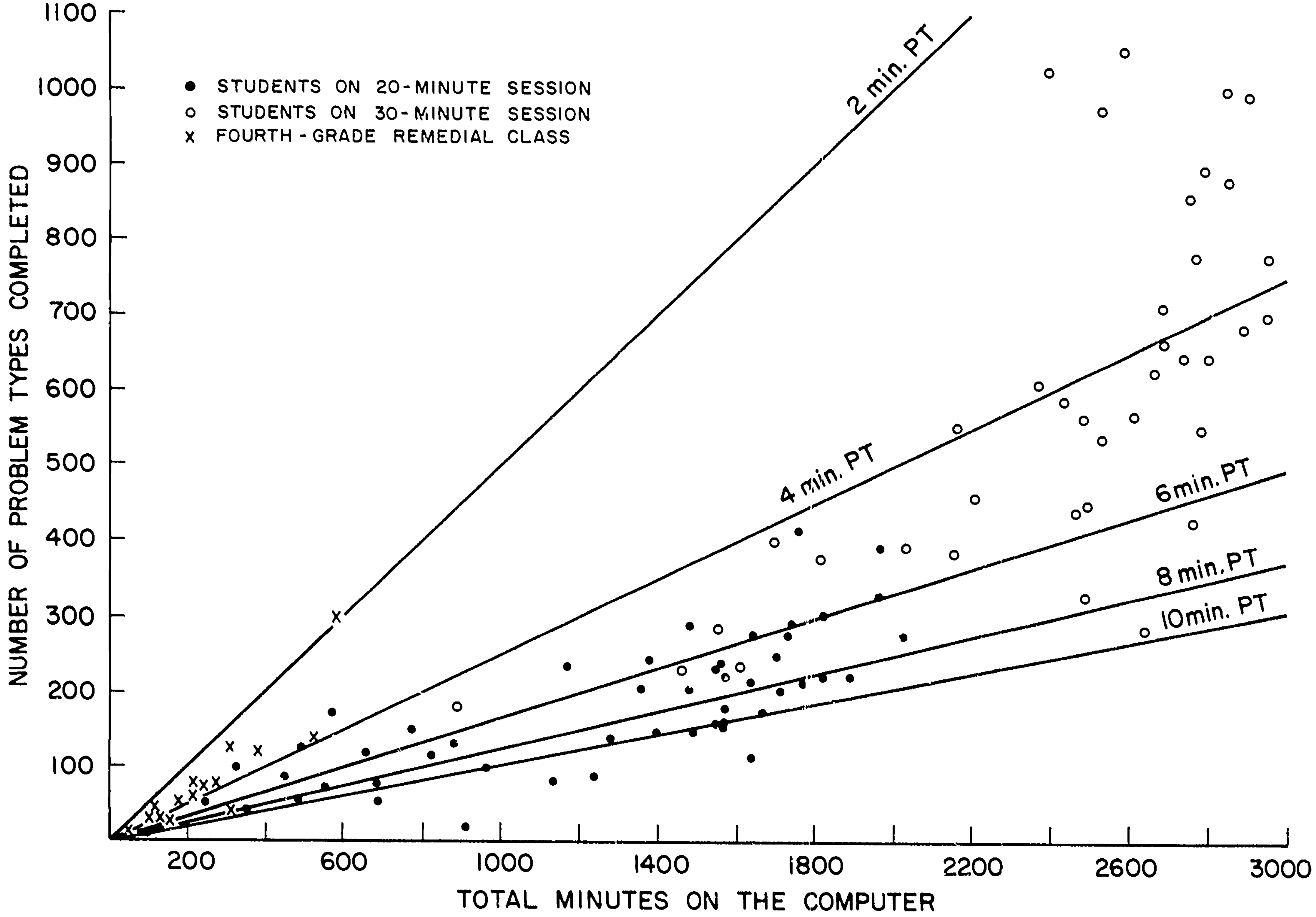

Fig. 2. Distribution of Students by Lesson Material and Time on Computer as of June 7, 1968, Brentwood Reading Curriculum

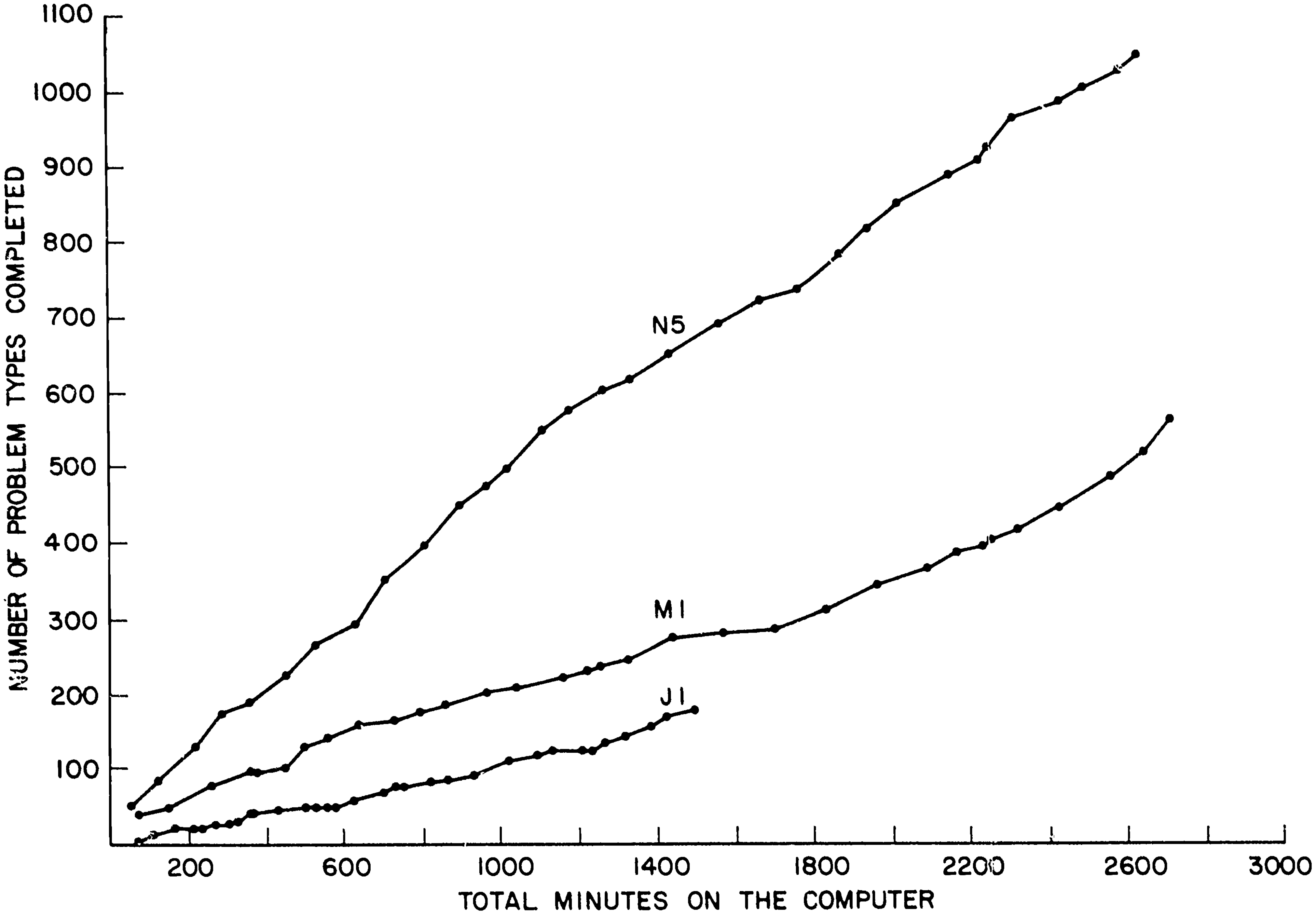

Fig. 3. Weekly Progress of Three Students from October 13, 1967 through June 7, 1968, Brentwood Reading Curriculum

confirmation that the curriculum accommodated individual differences in learning characteristics. Because of student transfers within and to the district, the children currently working in the early lessons of Level I are not those who began work in the program in September, 1967.

The increased difficulty of the lessons in Levels III and IV was reflected in the students' progress. In Level IV, the student encountered his first short reading stories; he read a story to himself using a controlled vocabulary, and if he needed assistance, he could initiate an audio reading by touching the light pen to the unknown word. This modification was received enthusiastically by students who reached this level.

Remedial fourth graders. In March, 1968, the fourth-grade teachers were asked to recommend students who could benefit from remedial help. These students and their parents were interviewed by the Principal who explained remedial computer-assisted instruction. Participation in the program was voluntary The children were asked to arrive a half hour before the normal class starting time every day, and those students who worked on the system on a regular basis found the program a successful learning experience. These students started at Level II; Figure 2 (p.17) indicates their progress. Because of their late entry into the program and the fact that attendance was voluntary, no pretesting was attempted and the collection of data was not documented. The teachers, however, did note an increased understanding and application of reading fundamentals in the classroom and, in most cases, definite improvement in attitudes and behavior of the students involved.

Student terminal behavior. Graduate students in the Experienced Teacher Fellowship Program observed and recorded student behavior and attitudes at the beginning and at the end of the school year. Table 6 indicates the results of the second observational study made in May, 1968, and may be compared with the corresponding table in the previous quarterly report. Again, eight basic categories of behavior were listed. Each child was observed for 5 minutes at the beginning, in the middle, and at the end of the class period. During each 5-minute period, the observer checked the type of behavior displayed every 15 seconds. Thus, for the entire sampling of students, any specific behavior could be observed a maximum of 20 times during any 5-minute period for a given student.

TABLE 6

Results of Children's Behavior Working at CAI Terminal, Brentwood Reading Curriculum

Observed behavior	Var. no.	Mean	S.D.	S.E. of Mean	Sample	Maximum	Minimum	Range
Looking at scope or projector	1	16.3	3.9	0.4	69	20.0	4.0	17.0
Twists in chair	2	3.6	3.2	0.3	69	11.0	0.0	11.0
Watching others	3	1.7	1.9	0.2	69	8.0	0.0	8.0
Looking over or under partition	4	0.0	0.0	0.0	69	0.0	0.0	0.0
Playing with keyboard	5	0.1	0.1	0.1	69	1.0	0.0	1.0
Playing with light pen	6	0.6	1.4	0.1	69	10.0	0.0	10.0
Playing with projector or scope	7	0.2	0.7	0.1	69	4.0	0.0	4.0
Looking or making faces in mirror	8	0.0	0.2	0.0	69	2.0	0.0	2.0

Variable 1 (looking at scope or projector) represented a desirable behavior, while Variables 2 through 8 were considered undesirable. Although Variable 2 (twists in chair) was considered an undesirable behavior, it was found that many students worked attentively and accurately while twisting and wiggling in their chairs. Some students worked out an almost rhythmic motion between responses which seemed to lend to rather than detract from their success at the terminals. Our data indicate that wiggling or twisting, toying with a light pen or watching other students did not necessarily impede student progress or success in lessons.

4. Data Analysis

Posttesting program. Students in the Experienced Teacher Fellowship Program from the Stanford Graduate School of Education were used as test administrators. They were trained and supervised in this task by Dr. Ruth Hartley of the Institute staff. The year-end testing program consisted of a battery of tests that measured achievement in each of the major areas of reading behaviors taught at the first-grade level. The behaviors identified and included in the testing program were: (a) identification of letter and letter strings; (b) acquisition of an initial sight vocabulary; (c) acquisition of word decoding skills; and (d) ability to use reading comprehension skills.

Since none of the available test batteries included tests of all the reading behaviors listed above, especially the measurement of a child's ability to decode words and the child's knowledge of syntax or form-class behaviors, two tests were devised by Dr. Hartley to fullfill this need.

The tests used in the May posttesting battery were the (a) Stanford Achievement Test, Reading Sections, Primary I Battery, 1964 edition; (b) California Reading Test, Lower Primary, Form W (1957); (c) Hartley Pronunciation Test, revised 1968 form; and (d) Hartley Recognition Test, 1967 form.

The Hartley Pronunciation Test in its revised 1968 form was used for data collection of the child's ability to pronounce word patterns taught by computer-assisted instruction. The data are available, and may be analyzed further by the continuation staff to evaluate the student's ability to pronounce the word forms in relation to his progress in the lesson material, if such information proves meaningful in the preparation of the drill-and-practice reading curriculum.

To provide a comparison between pretest and posttest scores, the following tests were given to the Brentwood CAI first graders: (a) Bender Gestalt (1964); (b) Peabody Picture Vocabulary Test, Form A (1959); and (c) Gilmore Oral Reading Test, Form B (1951).

Pretest and posttest gains. A lack of pretest information from last year prevented comparison of pretest and posttest scores for better evaluation of student progress. A battery of tests, including the Bender Gestalt, the Peabody Vocabulary, and the Gilmore Reading tests, were given in the fall of 1967 and in the spring of 1968 so that gain comparisons could be made. The results are presented in Table 7. There were marked gains in raw scores on each measure as was expected. These gains documented the fact that students learned to perceive shapes and relations and to recognize words and their meanings.

The mean gain of six points on the Peabody Picture Vocabulary Test and I.Q. measure was more noteworthy, since it indicated improvement on the raw score over and above improvement made by other students of the same age with similar raw scores. It is possible that these gains were the result of some influence other than the Reading Program. The pretest and posttest data are not available for other groups, so rigorous comparison cannot be made; however, survey data gathered from a similiar community and analyzed by Wilson (1967, pp. 165-206)[1] for the U. S. Commission on Civil Rights, indicate that it is common for low-achieving groups such as these to get even lower scores over a period of time. The gains on a verbal I.Q. measure are, therefore, of considerable interest.

Comparison of 1966-67 tests with 1967-68 tests. As shown in Table 8, this year's reading group scored significantly lower on the Peabody Vocabulary Test (I.Q.) than last year's reading and mathematics groups, even though the groups were completely comparable on the Stanford Binet (I.Q.).

Even though their verbal I.Q.'s were lower than the last year's mathematics group, this year's reading group did as well or better than last year's mathematics group on all subtests of the Stanford Achievement Test administered involving letter and word recognition (see Table 9). The differences on the word reading and word study skills subtests were statistically significant. The difference

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[1] Wilson, Alan B. Educational Consequences of Segregation in a California Community. Appendices: Racial Isolation in the Public Schools, Vol. 2. Report by the U. S. Commission on Civil Rights. Washington, D. C.: U. S. Government Printing Office, 1967.

TABLE 7

Mean Pretest, Posttest, and Gain Scores,
Brentwood Reading
1967-1968

	Pretest		Posttest		Mean Gain	Significance Level
	Mean	S.D.	Mean	S.D.		
Peabody Picture Vocabulary Test						
Raw score	51.6	6.75	57.4	5.88	5.8	$p < .00001$
I.Q.	87.2	15.49	93.2	12.11	6.0	$p < .00001$
Bender - Koppiz						
Errors	12.3	4.83	7.8	3.72	-4.5	$p < .00001$
Gilmore Oral Reading Test						
Correct words	3.7	9.95	91.8	74.22	88.1	$p < .00001$
Correct answers to questions	.3	.96	9.4	5.33	9.1	$p < .00001$

TABLE 8

Means and Standard Deviations of Fall I.Q. Scores,

Brentwood Reading, 1967-68

	Mean	S.D.	Significance Level
Peabody Picture Vocabulary Test - I.Q.:			
1966-67 Reading	95.3	14.53	p < .001
1966-67 Mathematics	93.8	15.22	p < .0001
1967-68 Reading	87.2	15.72	
Stanford Binet I.Q.			
1966-67 Reading	92.5	16.11	n.s.
1966-67 Mathematics	90.7	16.80	
1967-68 Reading	91.0	12.30	n.s.

TABLE 9

Comparison of the 1967-68 Reading Group with Control Group on Reading Achievement Tests

	Experiment		Control		Significance Level
	Mean	S.D.	Mean	S.D.	
Stanford Achievement Test					
Word Reading	18.8	7.81	16.4	6.51	$p < .01$
Paragraph Reading	14.5	8.57	13.8	8.98	n.s.
Vocabulary	17.9	5.18	17.3	5.48	n.s.
Word Study Skills	33.2	10.35	30.6	8.98	$p < .05$
California Achievement Test					
Letter Recognition	21.7	4.61	20.3	6.37	$.05 < p < .10$
Word Recognition	13.1	4.78	12.1	4.16	n.s.

on the California Achievement Test letter-recognition tests was marginal, the t value of 1.94 was .02 shy of the 1.96 required for an .05 level of significance. The other differences were not statistically significant, although they were in the hoped for direction.

The comparison of this year's reading group with last year's group shows mixed results as indicated in Table 10. Three of the differences favor the 1967-68 group, and three favor the 1966-67 group. The only statistically significant differences, those on the vocabulary and word study skill subtests, favor last year's group. Results for the 1967-68 reading groups would be better for all of the comparisons if the lower Peabody Picture Vocabulary Test (I.Q.) scores were taken into account as a covariant, but the correlations between PPVT (I.Q.) and the achievement subtests were sufficiently low so that the main pattern of results would be unchanged, therefore, this more complex analysis was omitted.

5. Form-class Study

This study was begun to determine if there is some evidence for the psychological reality of degrees of grammaticalness, and if there is, to determine if it implies some regular ordering of some set of complex symbol features in the lexicon of a transformational grammar.

Two related considerations in the development of an adequate transformational grammar are degrees of grammaticalness and the construction of the lexicon (Chomsky, 1965).[1] Chomsky suggests that lexical entries should be inserted into terminal strings on the basis of unique complex symbols, which will be associated with every lexical entry. For example, a lexical entry for "sand" might be <u>sand</u> [+ N + Det + Mass - animate]. Sand could be inserted then into any string which called for an entry with the complex-symbol configuration [+ N + Det + Mass - animate]. Sand would also be entered in the lexicon several times to account for other occurrences, each specified by an appropriate complex symbol. For instance, <u>sand</u> [+N - Det + Mass - animate] would have to be included in the lexicon to account for the grammatical occurrence of sand without a determiner as in the sentence, "The wind blew sand in his eyes."

Chomsky divides the complex-symbol elements into subcategorization features and selectional features. Subcategorization features reflect the more traditional grammatical categories, such as transitive verb, intransitive verb,

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[1] Chomsky, N. <u>Aspects of the Theory of Syntax</u>. Cambridge, Mass.: M.I.T. Press, 1965.

TABLE 10

Comparison of 1967-68 Reading Group with 1966-67 Reading Group

on Reading Achievement Tests

	1967-68 Reading Group		1966-67 Reading Group		Significance Level
	Mean	S.D.	Mean	S.D.	
Stanford Achievement Test					
Word Reading	18.8	7.31	18.0	5.83	n.s.
Paragraph Reading	14.5	8.57	13.0	9.46	n.s.
Vocabulary	17.9	5.18	21.4	5.41	p < .0001
Word Study Skills	33.2	10.35	36.5	9.19	p < .01
California Achievement Test					
Letter Recognition	21.7	4.61	21.7	4.25	n.s.
Word Recognition	13.1	4.78	13.7	4.59	n.s.

copula. Selectional features reflect those categories which are more often associated with semantics such as count, animate, and human. Intuitively, and according to Chomsky, sentences that violate subcategorization rules as in "John elapsed that Bill will come," are less grammatical than sentences that violate selectional rules as in the now classic example, "Colorless green ideas sleep furiously." Chomsky goes a step further, however, and extends this intuitively obvious connection between degrees of grammaticalness and the complex-symbol features to suggest that all the complex-symbol features may be ordered, and perhaps universally ordered, by the degree of grammaticalness or ungrammaticalness that results when a feature is ignored and its associated rules are therefore violated. For example, a sentence that violates the rules associated with the selectional feature Mass may be universally less grammatical than a sentence that violates the rules associated with the selectional feature Animate, or the reverse might be true. There may well exist a set of distinctive, binary complex-symbol features that might assume an order upon which most, if not all, linguists could agree.

These issues are more traditionally linguistic than psychological or educational, but, as is true of many linguistic issues, they may well have significant consequences for psychological theory and educational practice, and analysis of some of the Brentwood data, will be concerned with these issues. Most of this analysis will be concentrated on form-class items. Specifically, in the form-class item, Tim can fan $\left[\begin{array}{c} \text{ram} \\ \text{Nan} \\ \text{sad} \end{array} \right]$, "Nan" probably would attract the largest proportion of choices, since it yields a grammatically reasonable sentence; "sad" would attract the smallest proportion of choices, since its use would violate a subcategorization rule; and "ram" would fall some place between the proportion associated with "Nan" at the one extreme and those associated with "sad" at the other, since the use of "ram" could only violate a selectional rule. It is assumed that the greater the proportion of choice of a form-class item, the greater the degree of grammaticalness of the resulting sentence. If these proportions order themselves in a regular and predictable manner to some set of complex-symbol features, then we shall have at least the beginning of an empirical basis for the construction of the lexicon proposed for a transformational grammar of English.

C. Drill-and-practice Mathematics Program

1. Use of the System in Schools

The number of students given daily lessons increased during the quarter with the addition of Kentucky schools. The total number of students given lessons each day at each school in shown in Table 11. Students "signed on" the system at least 93,771 times--the total number of student entries in Table 11. A total of 300,561 lessons were given by the system during the three-quarter period which constituted the 1967-68 school year.

From April 4 to 6, a workshop for teachers and administrators was held at Morehead State University, Morehead, Kentucky. The workshop program emphasized (a) instructional objectives stated in behavorial terms; (b) projection of the year's mathematics work in detail, and selection of appropriate drill-and-practice lessons to supplement the planned course of instruction; and (c) practice on instructional terminals as students. In addition, workshop participants were given instruction on simple maintenance procedures for the instructional terminals.

Table 12 shows the actual number of students enrolled in the program as of June 30. Not included in this figure were 248 "lab" students (i.e., teachers). The total number of students, including teachers and aids, was 3,823. The numbers represent students taking lessons at a given grade level, regardless of actual grade placement in school with the exception of Peter Burnett, Garden Oaks, and Oak Knoll Junior High Schools. Even though the students were officially seventh, eighth, and ninth graders, they were working on lessons at the third-, fourth-, and fifth-grade levels.

Students in the Job Corps Center in Clinton, Iowa, were high-school age and older. These girls concurrently attempted to learn a trade and to earn a high-school diploma. As shown in Table 12, there was considerable variation in their ability as indicated by their assigned grade level. The majority of the students were working at the fourth-grade level.

The number of lessons given each day is graphed in Figure 4. Even though the data for two days were not available, comparatively, the total number of arithmetic lessons, tests, reviews, and logic lessons given last quarter (119,960) represents a rate increase since school was dismissed at the end of May in Kentucky and Mississippi.

TABLE 11

Number of Students Given Daily Lessons at Each School (Including Logic Students)

Drill-and-practice Mathematics

	April																May			
Calif. Schools	1	2	3	4	5	16	17	18	19	22	23	24	25	26	29	30	1	2	3	6
Lab	54	90	58	-	63	50	75	83	51	28	85	69	65	71	43	66	39	25	76	76
Grant	62	61	61	-	33	50	62	48	60	66	68	47	56	54	65	69	76	20	72	66
Garden Oaks	14	10	17	-	4	14	16	19	12	2	21	12	19	10	13	11	19	4	5	16
Peter Burnett	56	65	61	-	34	51	48	64	61	49	56	54	57	64	53	59	56	35	55	53
Walter Hays	265	241	279	-	231	281	254	257	216	239	228	245	238	185	169	204	241	138	227	269
Oak Knoll	139	120	142	-	75	124	151	136	120	128	119	113	104	96	106	95	155	83	147	155
Clifford	231	231	227	-	219	199	225	233	225	167	253	202	221	208	219	225	186	118	201	216
Fremont Hills	45	46	40	-	49	47	45	49	49	45	44	47	51	47	50	49	47	25	48	45
Sub-total	866	854	885	-	708	816	876	889	794	724	874	789	811	735	718	779	819	448	831	896
Miss. Schools																				
Eva Gordon	21	25	-	-	-	27	42	34	54	41	54	52	16	42	52	29	49	15	53	33
Alpha Center	34	37	40	-	38	31	25	20	34	26	40	37	35	30	39	34	40	3	39	22
Kennedy	19	18	23	-	16	15	14	-	14	14	17	-	-	6	24	14	23	4	11	9
Universal	95	87	101	-	89	72	95	61	93	78	95	87	99	98	94	69	105	12	102	41
Westbrook Elem.	54	58	43	-	44	49	51	23	55	44	31	25	48	27	36	36	21	4	39	26
Taggart	79	81	81	-	71	47	52	45	89	70	74	80	53	75	82	82	65	11	90	38
Netterville	29	13	32	-	35	35	37	31	46	31	35	33	33	46	28	35	35	1	30	10
Otken	77	55	46	-	50	59	71	51	87	50	61	70	49	50	58	73	73	9	99	48
Hughes	27	12	23	-	24	-	22	20	20	28	27	27	15	17	30	18	14	1	14	-
Summit	25	32	30	-	29	21	18	17	24	13	13	19	17	11	37	19	22	4	24	7
Franklin Center	107	62	103	-	65	78	74	72	108	39	81	87	81	94	87	57	37	10	76	40
Lillie M. Bryant	28	26	16	-	-	-	-	-	-	-	-	21	25	27	25	27	33	9	36	10
Sub-total	595	506	538	-	461	434	501	374	624	434	528	538	471	523	592	493	517	83	613	284
Iowa																				
Clinton Job Corps Ctr.	14	15	20	-	11	12	22	15	10	12	14	16	21	8	8	16	21	-	7	10
	14	15	20	-	11	12	22	15	10	12	14	16	21	8	8	16	21	-	7	10

TABLE 11 (cont'd)

Kent. Schools	April 1	2	3	4	5	16	17	18	19	22	23	24	25	26	29	30	May 1	2	3	6
Breckinridge	273	258	256	-	212	-	2	-	-	69	183	258	-	149	199	118	189	17	201	125
Morehead	251	177	292	-	256	154	271	-	-	216	108	209	-	189	194	211	214	15	179	183
Upper Tygart	-	-	-	-	-	-	-	-	-	-	-	-	-	47	50	43	61	7	58	48
Elliotsville	132	50	104	-	114	45	45	-	-	80	87	126	-	16	50	115	106	20	153	158
Sandy Hook	-	-	-	-	-	-	-	-	-	-	-	-	-	18	40	63	64	10	47	59
Flat Gap	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Paintsville	3	29	32	-	46	50	53	-	-	38	63	62	-	53	45	37	42	2	19	40
Sub-total	659	514	684	-	628	249	371	-	-	403	441	655	-	625	678	588	576	71	657	613

TABLE 11 (cont'd)

	May																		
Calif. Schools	7	8	9	10	13	14	15	16	17	20	21	22	23	24	27	28	29	30	31
Lab	75	72	79	44	77	107	62	105	26	83	168	101	106	122	45	66	76	55	91
Grant	24	48	54	55	74	30	40	51	41	36	39	46	25	38	33	36	28	-	-
Garden Oaks	12	14	12	[illegible]	11	10	5	19	3	5	8	13	9	6	7	12	9	-	4
Peter Burnett	39	27	45	53	54	59	64	71	24	61	50	53	61	41	50	50	57	-	5
Walter Hays	171	13	209	271	185	203	240	75	47	235	175	204	202	172	207	215	144	-	195
Oak Knoll	130	151	130	118	142	110	63	92	36	94	111	118	132	107	81	64	112	-	76
Clifford	157	217	194	196	205	225	240	225	103	224	201	220	217	199	186	194	208	-	-
Fremont Hills	43	49	53	55	54	45	47	42	23	46	18	47	45	55	44	55	47	-	46
Sub-total	651	571	776	839	802	789	761	680	303	784	770	802	797	730	653	692	681	55	414
Miss. Schools																			
Eva Gordon	14	55	63	11	22	41	5	25	14	41	29	42	28	7	-	1	-	-	-
Alpha Center	-	23	34	19	26	37	16	14	30	30	39	26	25	22	12	11	2	3	-
Kennedy	3	16	3	-	22	14	6	-	9	16	8	18	28	27	13	4	-	-	-
Universal	20	117	101	18	51	54	29	58	63	79	69	113	94	88	44	43	13	3	5
Westbrook	1	44	39	2	20	18	16	22	24	32	30	12	36	32	28	12	-	-	-
Taggart	16	81	64	18	50	74	38	70	50	62	44	58	30	99	84	99	84	114	52
Netterville	9	36	39	8	25	30	1	31	27	31	35	29	27	27	18	16	-	-	6
Otken	6	109	84	31	89	59	26	80	72	84	75	98	46	61	44	22	29	31	34
Hughes	3	23	3	8	2	14	-	28	7	27	24	18	4	-	4	17	4	1	-
Summit	-	29	23	-	15	-	-	9	16	20	18	33	-	2	2	3	-	-	-
Franklin	20	93	68	7	38	69	24	63	41	52	72	18	-	24	-	-	-	-	-
Lillie M. Bryant	9	37	35	9	28	11	7	32	23	27	30	28	-	19	-	-	-	-	-
Sub-total	101	663	556	131	389	421	168	432	376	501	473	493	358	408	249	228	132	152	97
Iowa																			
Clinton Job Corps Ctr.	11	43	12	24	15	33	34	14	19	26	13	28	33	24	20	12	20	-	15
Sub-total	11	43	12	24	15	33	34	14	19	26	13	28	33	24	20	12	20	-	15

TABLE 11 (cont'd)

Ky. Schools	May 7	8	9	10	13	14	15	16	17	20	21	22	23	24	27	28	29	31	1
Breckinridge	141	86	150	166	147	134	104	165	91	172	137	175	165	164	56	177	214	203	[illegible]
Morehead	168	119	160	163	140	157	110	144	104	145	135	131	185	185	156	113	114	149	[illegible]
Upper Tygart	63	65	71	57	53	59	56	55	51	66	54	58	53	47	64	[illegible]	43	52	[illegible]
Elliotville	138	74	101	116	115	101	82	105	57	86	66	98	92	94	93	90	72	92	-
Sandy Hook	54	12	5	66	61	62	31	59	39	52	50	47	59	36	59	[illegible]	52	-	17
Louisa	-	-	-	-	-	-	-	-	14	16	32	-	10	-	-	-	-	-	-
W.R. Castle	-	-	-	-	-	-	-	-	-	17	49	51	1	13	-	-	-	-	-
Flat Gap	-	-	-	-	-	-	-	-	-	13	34	42	37	2	-	7	-	-	-
Paintsville	24	16	34	31	42	40	17	35	25	38	33	12	27	35	18	45	6	3	24
Sub-total	588	372	521	599	558	593	400	563	381	605	590	614	630	576	446	529	501	499	[illegible]

TABLE 11 (cont'd)

Calif. Schools	June 3	4	5	6	7	10	11	12	13	14	17	18	19	20	21	24	25	26	27	28
Lab	16	40	49	35	19	14	42	5	90	13	95	121	77	147	38	58	67	68	3	50
Grant	37	32	45	64	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Garden Oaks	12	-	11	10	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peter Burnett	51	57	68	53	64	-	-	-	-	-	-	-	-	-	-	-	14	38	38	32
Walter Hays	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oak Knoll	114	106	82	97	77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clifford	206	213	208	205	168	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fremont Hills	51	-	40	45	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sub-total	487	500	503	510	379	14	42	5	90	13	95	121	77	147	38	58	87	106	41	82
Iowa																				
Clinton Job Corps Ctr.	17	-	-	7	-	4	12	1	5	-	-	-	-	-	-	-	7	-	-	-
Sub-total	17	-	-	7	-	4	12	1	5	-	-	-	-	-	-	-	7	-	-	-
Kent. Schools																				
Breckinridge	-	-	-	-	-	-	95	-	78	-	48	124	113	133	12	84	162	142	-	79
Elliotville	-	-	-	-	-	39	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Morehead	-	-	3	-	-	2	21	-	2	-	-	-	-	37	48	32	75	79	-	48
Paintsville	-	-	-	-	-	-	-	-	-	-	31	66	31	62	8	20	73	86	-	28
Upper Tygart	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	16
Sandy Hook	11	-	5	1	-	-	-	-	-	-	-	-	-	-	-	8	18	30	-	-
Louisa	-	-	-	-	12	-	-	-	31	-	-	-	11	9	1	1	18	30	-	22
W.R. Castle	-	-	-	-	-	-	-	-	-	1	2	-	21	15	-	-	30	66	-	33
Flat Gap	-	-	-	-	-	-	-	-	-	-	-	-	-	5	16	19	54	43	-	19
Pikeville	-	-	-	-	-	-	-	-	-	15	-	-	23	26	-	22	45	33	-	-
Sub-total	11	-	8	1	12	41	119	-	111	16	81	190	199	287	85	186	475	509	-	245

Note: Table shows gross count of all students who started lessons.

TABLE 12

Total Number of Students Working at Each Grade Level in Each School as of June 30, 1968.

Drill-and-practice Mathematics

	Grade Level									
Calif. Schools	1	2	3	4	5	6	7	8	9	Total students
Grant					22	74				96
Garden Oaks						32	10	10		52
Peter Burnett							30	45	28	103
Walter Hays	67	71	62	82	110	69				461
Oak Knoll	31	36	53	5		1	25			151
Clifford	33	49	60	44	53	30				269
Fremont			38		13	10				61
Sub-total	131	156	213	131	198	216	65	55	28	1193
Miss. Schools										
Eva Gordon				38		29				67
Alpha Center	22					14				36
Kennedy						29				29
Universal	34			26		41				101
Westbrook				32		27				59
Taggart	25					29				54
Netterville		31								31
Otken			33	1	36	37				107
Hughes						29				29
Summit						30				30
Lillie M. Bryant					29					29
Franklin						68				68
Sub-total	81	31	33	97	65	333				640
Iowa										
Clinton Job Corps Ctr.	3	6	13	88						110
Sub-total	3	6	13	88						110

TABLE 12 (cont'd)

	Grade Level									
Miss. Schools	1	2	3	4	5	6	7	8	9	Total students
Breckinridge	30	37	30	33	27	31				188
Elliotville			37	29	32	33				131
Morehead	36	32	27	76	32	73				276
Paintsville	14	8	95	87	70	92				366
Upper Tygart			37		26					63
W.R. Castle			48	55						103
Pikeville		59	59	62	34	33				247
Flat Gap			58	47						105
Louisa			46		43					89
Sandy Hook			32		32					64
Sub-total	80	136	469	389	296	262				1632
Total	295	329	728	705	559	811	65	55	28	3575

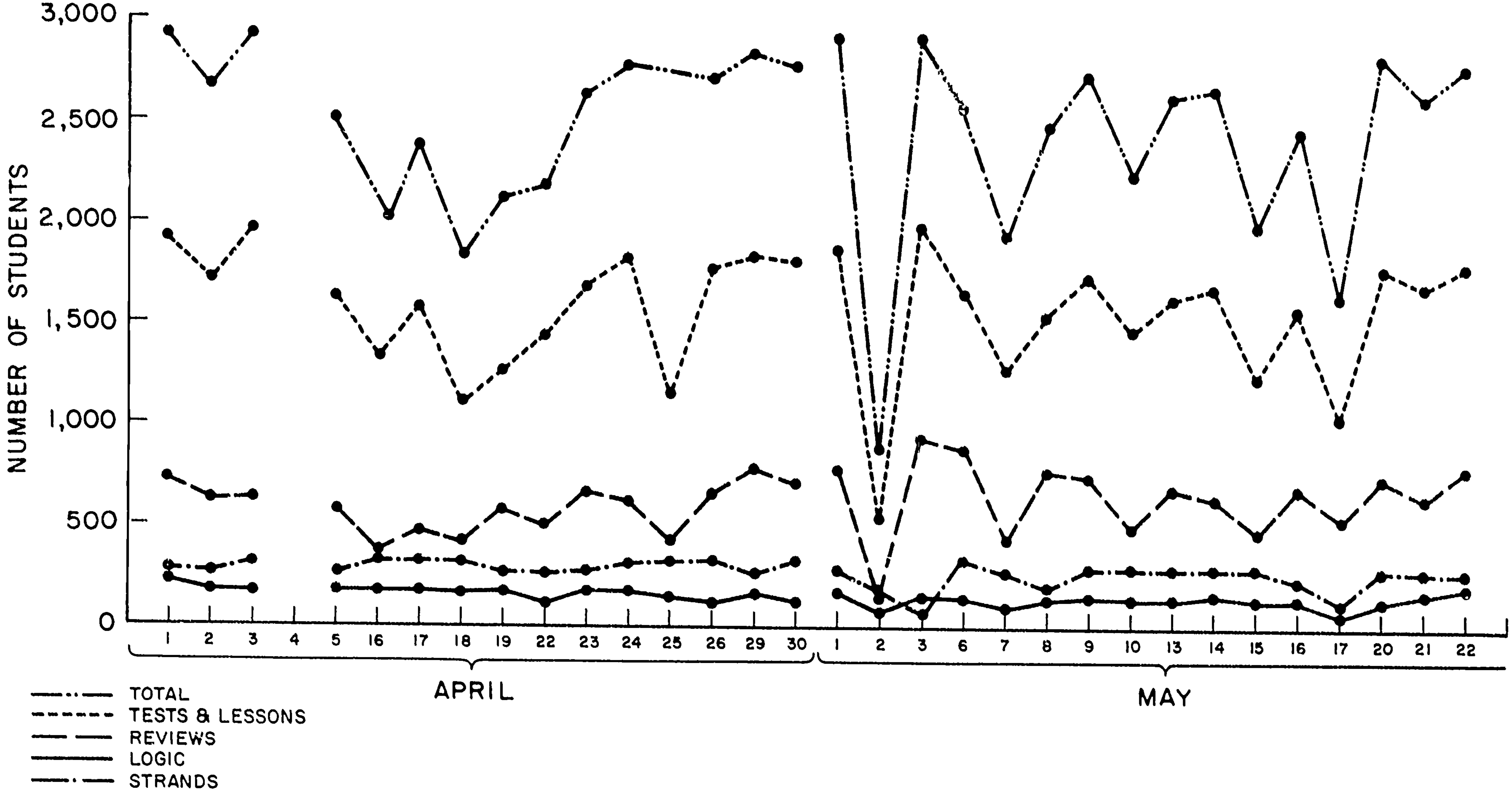

Fig. 4. Number of Lessons Given Daily in Teletype Drill and Practice in Arithmetic

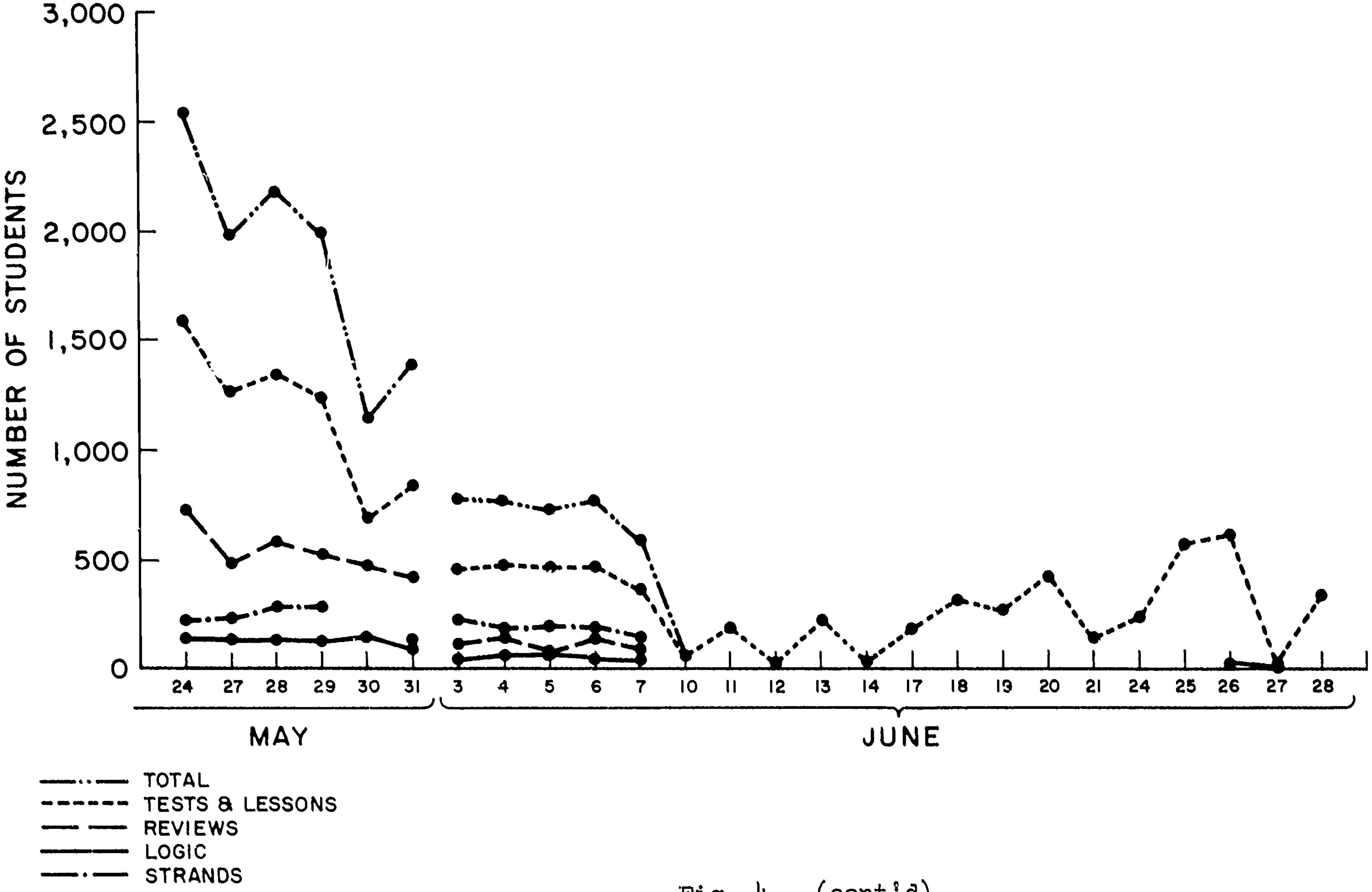
3,000
2,500
2,000
1,500
1,000
500
0
NUMBER OF STUDENTS
24
27
28
29
30
31
3
4
5
6
7
10
11
12
13
14
17
18
19
20
21
24
25
26
27
28
MAY
JUNE
TOTAL
TESTS & LESSONS
REVIEWS
LOGIC
STRANDS

Fig. 4. (cont'd)

The percentage of students in California schools who completed each concept block is shown in Table 13. Tables 14 and 15 show the percentage of Kentucky and Mississippi students who completed each concept block.

The number of tests or lessons given on the last day for this reporting period is shown in Table 16, as is the distribution of students over concept blocks at each grade level. The results presented in this table emphasize the demands for flexibility imposed on a system by a program which stresses individualization. Nearly every concept block at each grade level was sampled by some student during the day. Considering that the first 24 blocks at each grade level contain the planned content, this table shows that on May 22, more than 88 per cent of the total curriculum data base was sampled. The ability to have available the entire program at each grade level, together with a rapid system response to each student's input, has contributed significantly to the success of the program.

Table 17 presents the number of reviews sampled on May 22. As would be expected, the number of review blocks sampled is fewer than the number lessons. Since it is nearly impossible to predict what review blocks will be needed on any given day, it is necessary to have all review blocks available.

2. Curriculum Revision

Revisions of the strands program were begun during this reporting period. No extensive revisions to other programs were made. Revisions on the regular drill-and-practice program were completed during the previous reporting period.

3. Strands Program

California students continued to use addition, subtraction, and multiplication strands in place of their daily review lessons during this reporting period. Students in grades 1 through 3 worked in addition and subtraction strands, students in grades 4 and 5, in multiplication and subtraction strands. The subtraction strand was replaced by the fraction strand early in April. Each student was given seven problems from each strand each day as a review lesson.

TABLE 13

Percentage of Students Who Have Completed Each Concept Block in California Schools as of June 13, 1968, Drill-and-practice Mathematics

			Grade			
Block	1	2	3	4	5	6
1	57	84	100	99	69	100
2	57	54	100	97	86	98
3	57	54	99	96	79	89
4	57	54	99	92	95	88
5	57	54	99	90	69	85
6	56	54	98	64	67	84
7	56	53	97	15	81	80
8	56	53	90	84	63	81
9	55	50	65	30	74	60
10	53	62	81	82	73	65
11	49	45	50	77	40	69
12	45	44	76	83	75	52
13	36	40	73	76	65	48
14	29	36	28	60	24	54
15	25	28	39	34	52	21
16	23	22	57	40	55	77
17	22	19	45	4	32	8
18	16	8	62	51	11	2
19	11	3	25	6	12	2
20	1	0	4	0	7	1
21	0	0	18	0	0	1
22	0	38	58	45	45	44
23	0	0	5	0	0	0
24	0	0	0	0	29	0
25	0	1	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	14	0
28	0	0	0	0	65	0
29	0	0	0	8	15	0
30	0	0	0	1	4	9

TABLE 14

Percentage of Students Who Have Completed Each Concept Block in Mississippi Schools as of June 13, 1968, Drill-and-practice Mathematics

	Grade					
Block	1	2	3	4	5	6
1	100	67	100	91	98	99
2	100	64	100	91	96	99
3	98	57	90	78	71	98
4	98	56	85	85	96	98
5	97	55	75	81	97	92
6	97	54	65	78	95	69
7	97	69	61	0	94	87
8	96	64	74	74	61	72
9	93	63	48	66	95	71
10	88	97	48	61	59	30
11	87	90	45	50	90	74
12	86	87	41	50	58	26
13	81	87	38	57	27	44
14	77	80	1	49	29	96
15	64	43	0	57	7	73
16	58	70	49	68	14	56
17	43	68	0	39	47	62
18	42	63	0	18	1	26
19	35	48	49	0	0	8
20	31	20	0	0	0	6
21	50	11	0	0	8	5
22	35	0	0	27	10	7
23	35	0	0	8	12	11
24	26	2	0	0	82	0
25	0	11	0	0	25	0
26	0	0	0	0	43	0
27	0	65	0	0	66	0
28	0	0	0	9	100	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0

TABLE 15

Percentage of Students Who Have Completed Each Concept Block in Kentucky Schools as of June 13, 1968, Drill-and-practice Mathematics

	Grade					
Block	1	2	3	4	5	6
1	100	100	52	35	100	90
2	100	100	42	0	91	90
3	100	100	12	0	5	85
4	100	100	24	3	3	55
5	100	13	29	69	33	39
6	100	100	35	70	23	39
7	98	100	40	88	37	48
8	98	100	24	47	37	48
9	98	100	34	23	41	68
10	90	100	34	36	36	65
11	44	98	26	18	23	68
12	38	97	23	14	29	8
13	34	97	18	1	22	48
14	63	94	6	0	20	59
15	30	82	0	0	10	50
16	13	49	0	0	0	19
17	4	44	0	0	0	3
18	0	44	0	0	0	0
19	0	43	0	0	0	0
20	0	43	0	0	0	0
21	0	75	0	0	0	0
22	0	72	0	0	0	0
23	0	62	0	0	0	0
24	0	51	0	0	7	0
25	0	34	0	0	21	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0

TABLE 16

Number of Tests or Lessons Per Grade and Concept Given on May 22, 1968.

Drill-and-practice Mathematics

	Grade					
Block	1	2	3	4	5	6
1	0	5	46	8	9	1
2	1	14	[illegible]	4	51	0
3	3	5	7	15	11	3
4	[illegible]	1	6	11	0	9
5	[illegible]	1	6	9	8	1
6	1	4	33	20	9	7
7	1	9	20	11	2	6
8	6	5	7	53	7	7
9	17	6	17	9	2	12
10	23	5	25	12	12	15
11	7	5	45	22	18	19
12	12	8	6	34	19	18
13	17	3	26	7	6	26
14	20	12	45	9	14	2
15	17	29	12	10	39	25
16	13	10	7	16	18	31
17	9	12	2	12	16	19
18	15	10	30	23	13	25
19	8	22	13	8	8	7
20	0	14	0	0	14	6
21	4	17	12	0	1	0
22	1	11	16	15	21	20
23	1	2	2	9	10	6
24	12	2	0	0	13	0
25	0	15	0	0	6	0
26	0	0	0	0	4	0
27	[illegible]	[illegible]	[illegible]	0	3	0
28	0	0	0	1	0	0
29	0	0	0	0	6	0
30	0	0	0	0	2	4

TABLE 17

Number of Reviews Per Grade and Concept Given on May 22, 1968, Drill-and-practice Mathematics

	Grade					
Block	1	2	3	4	5	6
1	5	0	2	4	3	3
2	5	2	3	9	5	2
3	0	0	7	7	13	19
4	10	1	8	0	1	5
5	2	2	1	10	5	21
6	5	3	4	15	1	3
7	5	1	14	4	2	1
8	2	1	7	6	25	20
9	14	6	22	5	12	28
10	5	5	5	1	9	13
11	6	4	30	1	0	0
12	16	1	4	21	29	0
13	15	5	1	1	6	13
14	5	13	0	0	5	21
15	0	4	0	0	3	0
16	0	4	18	13	5	6
17	0	3	0	3	0	4
18	7	3	2	1	2	11
19	1	1	0	0	0	1
20	0	13	0	0	0	0
21	4	1	0	0	1	0
22	2	9	5	5	0	12
23	1	1	0	0	0	0
24	4	3	0	0	0	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	1	0

The number of students in each equivalence class in each strand is shown in Table 18.

TABLE 18

Number of Students in Each Equivalence Class in Each Strand as of May 27, 1968, Drill-and-practice Mathematics

Strand	Equivalence class											
	1	2	3	4	5	6	7	8	9	10	11	12
1 Addition	4	20	28	27	41	23	35	30	13	16	14	1
2 Subtraction	35	60	84	93	77	62	28	19	21	6	5	
3 Multiplication	25	25	59	65	86	47	27	11	3			
4 Fractions	62	44	3	1								

The problem types included in each strand were listed in the report for the previous period.

4. Problem Solving

The problem-solving program was developed to examine the factors involved in teaching fifth graders how to use the computer as a desk calculator to solve multistep word problems. It was also designed to permit investigation of variables which might contribute to problem difficulty. Twenty-seven fifth-grade students completed the 68-problem sequence during this reporting period.

Data analysis continued during this reporting period, using as variables in a linear-regression program, the total number of words in each problem, the minimum number of operations required for solution, and the minimum number of different operations required.

5. Theory of Automata

The data analysis group during the present quarter has been developing automata for various arithmetic problems. The examination of parameters may provide the ability to define methods used by students to solve various types of problems. For a given automaton, models which differ in terms of the possible sources of student errors can be examined and, for a given problem type, more than one automaton can be developed.

An automaton is a logical structure which provides a formal description of algorithms for solving certain mathematical problems It may be compared to a hypothetical machine which operates sequentially on the objects fed into it. The machine may be in one of several possible states. At each discrete time point, an element from a set called the alphabet is fed into the machine. The machine performs two operations: (a) it produces an output; and (b) it may change its state. Both operations depend only on the state of the machine and the most recent input. An automaton is formally defined as the following structure: $(A, \Sigma_I, \Sigma_0, M, Q, s_0)$, where A is the collection of possible states, Σ_I is the collection of possible input characters (input alphabet), Σ_0 is the collection of possible output characters (output alphabet), M is a function from $A \times \Sigma_I$ to A which determines the state of the machine, Q is a function from $A \times \Sigma_I$ to Σ_0, which determines the output character, and s_0 is the initial state of the automaton.

For example, the most common algorithm for finding the difference between two integers is to operate column by column from right to left, borrowing when necessary from the next column. This process is described formally by the following automaton.

$$A = \{0,1\}$$

$$\Sigma_I = \{(m,n): 0 \leq m, n \leq 9\}$$

$$\Sigma_0 = \{0,\ldots 9\}$$

$$M(k,(m,n)) = \begin{cases} 0 \text{ if } m - k - n \geq 0 \\ 1 \text{ if } m - k - n < 0 \end{cases}$$

$$Q(k,(m,n)) = \begin{array}{l} m - k - n \text{ if } m - k - n \geq 0 \\ m + 10 - k - n \text{ if } m - k - n < 0 \end{array}$$

$$s_0 = 0$$

The state 1 corresponds to having borrowed on the previous column. Since there can be no borrow initially, s_0 is set to 0. Consider the problem: $\begin{array}{r} 54 \\ \underline{-26} \end{array}$. The solution is obtained by the following steps.

$$s_0 = 0$$

$$Q(0,(4,6)) = 8$$

$$M(0,(4,6)) = 1$$

$$Q(1,(5,2)) = 2$$

$$M(1,(5,2)) = 0$$

Any deterministic automaton may be generalized by introducing transition and output probabilities in place of functions. For the analysis of student data, this generalization is necessary in order to account for the possibility of error. For example, the subtraction automaton may be altered by introducing three parameters γ, ε, and η, which correspond respectively to the probability of an output error, the probability of an error in transition to the "no borrow" state, and the probability of an error in transition to the borrow state. In terms of the functions M and G, the parameters γ, ε, and η are defined as follows:

$$P(Q(k,(m,n)) = m - k - n \mid m - k - n \geq 0) = 1 - \gamma$$
$$P(Q(k,(m,n)) = m + 10 - k - n \mid m - k - n < 0) = 1 - \gamma$$
$$P(M(k,(m,n)) = 0 \mid m - k - n \geq 0) = 1 - \varepsilon$$
$$P(M(k,(m,n)) = 1 \mid m - k - n < 0) = 1 - \eta.$$

With certain assumptions concerning the independence and noncontingency of errors, the maximum likelihood estimators for the three parameters can be obtained.

D. Logic and Algebra Program

1. The First-year Program

Student progress. Of the 170 first-year logic students, 9 completed the first-year materials and continued with the second-year materials. Another 5 were working in the last lesson. The rate of progress slowed as the schools became more preoccupied with year-end activities.

Figure 5 compares the number of problems completed by each student with the number of sign-ons at the end of the school year. The scattergram indicates that the faster students worked two or more times as fast as the slower students. Some students entered the program late, others dropped out early, or were quite irregular in participating in the program. Several students frequently signed on more than once a day. Ten students signed in more than 150 times. They were particularly enthusiastic students who came early, stayed late, and used recess time to work at the teletypes. Students above the 896-problem level had progressed into second-year materials. One student nearly completed the entire two-year program, another was a close runner up.

Audio link. This program continued but was used progressively less by the students. This may indicate that the dialogue had helped those students who had used it to develop strategies of proof that further improved their self-reliance.

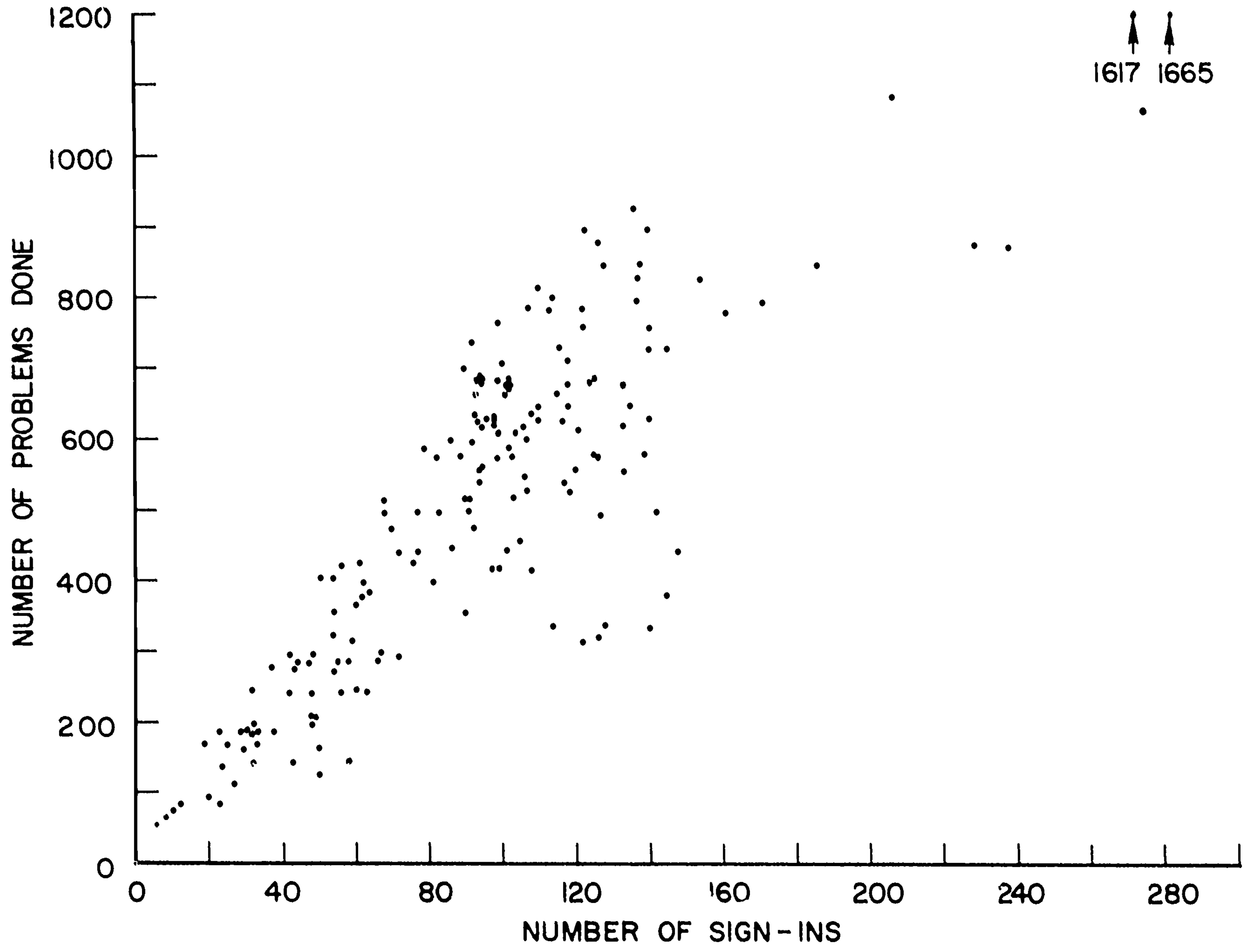

Fig. 5. First-year Logic Student Achievement

The taped dialogues were transcribed for reference use in the planning for automated dialogue.

Logic dialogue. On the basis of the audio-link experience and the experience of four of the staff members who supervised the teletype room at Walter Hays School where first- and second-year logic-algebra programs were run, detailed plans for a help-routine dialogue were written. Basically the dialogue consists of sets of questions given by the computer, typed out or presented auditorily, to which the student replies by typing one or two characters. The aim is to help the student devise a proof strategy for problems with which he is having difficulty.

2. The Second-year Program

Lesson writing and coding. Lessons dealing with the axioms for multiplication, indirect proof, and some further theorems were written and coded.

Student progress. Students worked as teams proving elementary theorems about additive groups. Student moral and enthusiasm were higher when they worked in teams. Some student teams completed the theorems and began work on the axioms for multiplication. It is anticipated that curriculum revision will allow students to complete a greater portion of the material. Students continued to participate in the audio-link program.

3. The Third-year Program

Since the third-year program progressed satisfactorily and was not needed for the beginning of the 1968-69 school year, most of the time was devoted to writing the dialogue for the logic program. Only at the beginning of the reporting period was any work done on the third-year algebra. A few more lessons on word problems were written and detailed plans were made for the lessons on simultaneous linear equations.

4. Data Analysis

The rank ordering of 17 logic and algebra rules of inference, in terms of mean latency, is shown in Table 19. These are the 17 rules used in the first half of the course. It is probably a fair inference to hold that the mean latency for each of the rules, which is based on summation over the students and occurrences of the rules in the students' proofs, is a good measure of relative difficulty. Perhaps the most important observation to be made about the data of Table 19 is that the six algebraic rules of inference are among the

TABLE 19

Rank Ordering of Algebraic and Logical Rules of Inference on the Basis of Mean Response Latency

Rank	Rule	Latency in sec.	Number of occurrences of rule in data
1	ND (Number Definition)	2.93	2,589
2	D (Definition)	2.94	4,732
3	CA (Commute Addition)	3.42	2,885
4	LC (Left Conjunct)	4.06	25
5	AR (Associate Addition Right)	4.09	1,419
6	AL (Associate Addition Left)	5.36	103
7	CD (Commute Disjunction)	5.75	41
8	ID (Inverse Definition)	6.11	361
9	AA (Affirm the Antecedent)	6.24	482
10	FD (Form a Disjunction)	6.34	325
11	DN (Double Negation)	7.12	244
12	CC (Commute Conjunction)	8.42	41
13	DC (Deny the Consequent)	9.16	302
14	DD (Deny a Disjunct)	11.73	219
15	HS (Hypothetical Syllogism)	11.79	137
16	FC (Form a Conjunction)	12.63	33
17	RC (Right Conjunct)	13.07	19

first eight rules in rank ordering. The definitional rule ND had a mean latency of 2.93 seconds and the longest latency for any of the algebraic rules was for the inverse rule ID, which had a mean latency of 6.11 seconds. Before a hasty inference is made to the conclusion that algebraic rules of inference are easier than those of sentential logic, it is important to keep in mind that the six algebraic rules each require reference only to a single preceding line, and in the present context, this reference to the preceding single line was restricted to the immediately preceding line, which simplifies very much the search procedure the student must follow in deciding what rule to apply and where. The greater ease of application of the algebraic rules does suggest however that it would be wise to emphasize these rules at the beginning of the course. The data do show too that mastery of these algebraic rules is probably easier for students than mastery of the beginning rules of sentential logic.

The number of occurrences of each rule in the data, as summed across students and problems, is also shown in Table 19. We believe that the large discrepancy between the mean latency for LC and RC, which are conceptually so closely related, is not to be taken seriously in the present data, because there were only 25 occurrences of the use of LC and only 19 of RC. The logical rule CD also had only 41 occurrences in the data. If we exclude LC and CD, no other rule of logic had a mean latency as short as any of the six rules of algebra. On the other hand, as might be expected, the rule of logic that follows immediately after the algebraic rules, with the exception of LC and CD, is AA, which is classical modus ponendo ponens, and which had by far the most frequent occurrence in the data. Four of the six algebraic rules had very frequent occurrence, being used a good many times more than even the most frequent logic rule. This circumstance undoubtedly also helped produce the shorter latencies for the algebraic rules.

5. Logic and Algebra Computer Programming

Minor improvements were made to enhance systems performance for the logic and algebra programs. The data recording mechanism was improved by eliminating the recording of irrevalent or unused data.

The dialogue program to be implemented during fall 1968 is beyond the preliminary design stages. Programming for this effort is temporarily delayed, however, so that the PDP-10 version of the logic and algebra program can be successfully implemented by October 1, 1968.

E. Dial-a-drill Program

1. Student Enrollment

Twenty students, 6 in the second grade, 2 in the third grade, and 10 in the fourth grade, received daily dial-a-drill lessons during the first part of this reporting period.

2. Experimental Projects

The following two experiments were concluded:

1. A comparison of levels reached by students using two different branching criteria: (a) after each problem in a strand; or (b) after each set of 10 problems in a strand.
2. A study of the relative difficulty of different types of fraction problems.

Experiment 1. Problems in each concept strand were arranged in sequential levels of difficulty. This experiment examined student progress under two different decision rules. Either a student advanced to the next higher level of difficulty as long as he continued to solve each problem correctly, or his performance was evaluated after completion of 10 problems from a level rather than after a single problem.

Beginning February 12, the 12 students in the program at that time were assigned by the experimenter to two groups, A and B, without their knowledge. Students in Group A were branched on the single-problem basis and students in Group B were advanced on the 10-problem basis. For an eight-week period, each group worked under one or the other assigned decision rules for a four-week period, and then the alternate rule was assigned, again without their knowledge.

The decision rules for branching for the single-problem group were: move up one level if the first response was correct; remain at the same level if the first attempt was incorrect, but the second response was correct; and move down one level if an error was made on the second attempt for any problem.

The decision rules for the 10-problem group were as follows: responses correct on the first attempt were worth 2 points and responses correct on the second attempt, following an error or time out, were worth 1 point. A score of 18-20 points advanced a student to the next higher level and a score of less than 14 points dropped a student to the next lower level. Otherwise, the student remained at the same level of difficulty.

During the first four weeks of the experiment, it was clear that the change after each problem produced an initial rise in levels, followed by a more-or-less consistent fluctuation over 3 to 5 levels of difficulty.

Students in Group B, on the other hand, moved downward as a result of the somewhat more restrictive criteria; however, a small number of Group B students reached the higher levels.

The individual divergence in achievement was so general that it did not seem valid to use any average-level measure of the effectiveness of the two schemes.

The students appeared to prefer the one-question system, especially the more able children who were able to reach the more difficult problems. Although the level of difficulty of questions was higher generally, students on this part of the experiment completed more questions in their 5-minute drills than in the other part. The medians were 16 and 14 questions.

Children who joined the program after the start of this experiment were placed on the one-question scheme. This, with the higher rate referred to above, gives the higher number of questions attempted on that scheme, 6,049 compared with 3,470.

Experiment 2. Fractions. Six children at fourth-grade level or above were given fraction problems at the start of each lesson for a four-week period. The problems were the same for each student (i.e., one each of six different types of problems specified for the fraction strand). Examples of the questions used follow:

How many ninths are four sixths?
Three sixths are four over what?
How much is one fifth of ten?
How much is one eighth plus five eighths?
How much is four sevenths minus one seventh?
How much is one half times one half?

This program allowed 30 seconds for a response. The system checked each response for extraneous characters, which took somewhat longer than usual to process. The children noticed the delay in response time and were somewhat irritated by it.

Students made very little use of the option to input answers in simpler terms such as 1/2 or 4/8, but this was probably lack of confidence in the program's ability to accept them. A factor in this may have been the failure to accept 6/9 as correct where only 6 was expected.

Although only the range from halves to ninths was used, there was evidence that there was more confidence in handling halves, thirds, and fourths than other fractions. In level 8, for example, all but 2 of the second-try correct responses and all of the time-outs were for questions involving fifths or smaller fractions.

F. Elementary Russian Program

1. Preparation of Material

Computer-based lessons. The first version of our computer-based course in elementary Russian was completed during this quarter. A total of 135 lessons, including review lessons, were entered into the computer and are available for use.

Homework assignments, study sheets, and summaries. Homework and study sheets were prepared for lessons 93-135 and issued to students as they progressed through the last quarter's work. At midterm, a summary was prepared and issued. Before the final examination of the year, the full year's grammar and vocabulary summaries were prepared and distributed.

Language-laboratory tapes. Twenty pronunciation tapes were produced and made available to students. Each tape ended with dictated Russian sentences which the students were required to write down and turn in for correction.

Pronunciation evaluation tapes. The pronunciation of students continued to improve and their achievements in this respect, as well as their accuracy in spelling, have been most gratifying. In the course of the final quarter, two tapes were made of students reading.

2. Supporting Programs

Work continued on the revision of material in earlier parts of the course, including certain modifications in the vocabulary sequencing.

Major progress was made in the development of nested remedial blocks designed to individualize instruction by branching a student to different remedial material, depending on the location of his mistake in a sentence. Routines are nearing completion which will generate for each Russian word a remedial block calling on the student to (a) produce the basic form of the vocabulary item in question; and (b) generate the form needed from the basic form. Eventually, failure to respond correctly to the first type of item will be noted as a vocabulary deficiency, failure in the second type will be correlated with a coded set of grammatical rules, and the rule involved listed for future review.

3. Data Analysis

The data analysis is in progress. Some results should be ready for inclusion in the final report for the year.

Examination results. The midterm examination for the spring quarter contained a larger percentage of common sentences (about 80 per cent) than had previous examinations. Results are given in Table 20. Since particular attention was devoted during the last quarter of the course to the coverage of vocabulary material covered by the regular group, it was decided that the large percentage of overlap justified giving an identical final examination to both the computer-based and the regular students. The results of this examination are given in Table 21.

While detailed analysis of the results of the final examination must await the final report, it seems clear that the computer-based group fared better. The difference in the dropout rate of the two groups of students is of added significance. Out of 29 computer-based students who took the first quarter's final examination, 24 computer-based students and 16 regular students remained to take the final examinations for the third and final quarters of the year.

4. Videotapes

The preparation of Russian videotapes continued this quarter. Special attention was given to evaluation of the lessons. With the completion of one additional lesson, a total of six lessons are available.

TABLE 20

Results of First-year Russian Spring Quarter 1968 Midterm Examination

(Common Portion)

Number of errors	Number of Students	
	Computer-based	Regular
4.5		1
5.5	1	
6	1	1
6.5	1	
7.5	1	
8	1	1
8.5	1	
9	1	
10		1
11		1
12.5	1	
13	1	1
13.5	2	1
14	2	
14.5	1	
15	1	1
16		3
17	3	1
17.5		1
18.5		1
19	1	
20.5	1	
21.5	1	
22.5	1	
23	1	
35		1
43	1	
43.5		1

Total Students	24	16
Total Errors	361.5	260.5
Mean	15.1	16.3
Overall Mean	15.6	

TABLE 21

Results of First-year Russian Spring Quarter 1968 Final Examination

(Common Portion)

Number of errors	Number of Students Computer-based	Regular
21.5	1	
24.5	1	
26	1	
27	1	
31.5	1	
32	1	
34		1
35	1	
37	1	1
39		1
40	1	
41		1
42	1	
45	1	
46		1
47.5	1	
50.5		1
51.5	1	
60	1	1
61	1	
63.5		1
67		1
69	1	
69.5	1	
73	1	
74.5	2	1
76.5	1	
80.5		1
81	1	
82	1	
89		1
91		1
92		1
93	1	
106		1
166		1

Total Students	24	16
Total Errors	1,274.5	1,137
Mean	53.01	71.06
Overall Mean	60.29	

The lessons were presented to a group of twelve-year-old students at a local school over a period of several weeks. Based on the findings of this and other tests, certain modifications will be made. Also, construction was begun on devices to place a coding rack on all tapes. The coding will identify the phase of the question-response-reinforcement cycle and the correct answer to each question. When used with suitable answer devices (e.g., push-button telephone pads) and a computer-like recording device, the coding track will make possible the immediate grading of lessons for large numbers of students and the collection of latency data. This information will make evaluation of the lessons more rapid and thus more fruitful.

G. Spelling Program

1. Enriched Evaluation of Student Performance

A study was designed to assay the effects of the enriched context in which spelling words were presented. This enriched context consisted mainly of positive, conversational evaluations of each child's performance on each word.

Compare the first two evaluation examples with the second two:

Child's Response	Computer "Evaluation"
WONDOR	NOT QUITE, CAN YOU FIND YOUR MISTAKE
INSIDE	GOOD WORK, YOU GOT IT RIGHT
WONDOR	.X.
INSIDE	.C.

By presenting words evaluated by each kind of comment to each child, data were collected which will be used to evaluate the effectiveness of this approach.

2. Student Use of Terminals

The number of children served at the four teletypes each day continued to be just above 50. The few days in June were used to demonstrate the program to other children and, with an abbreviated demonstration lesson, more children were served.

The daily averages for each month were:

Month	Number of Days	Number of Children per Day
April	17	51
May	19	53
June	5	75

3. Phasing-out of CBI-spelling Project

A final activity for this quarter was the phasing-out of the computer-based instruction spelling project at Costano School. Other programs replaced this project at the school and, to help in the transition and to give the children something to look forward to over the summer, the last week of the project was used to give several classes a chance to interact with the Spelling Drill Driver. Reactions of the children were quite positive.

4. Data Analysis

The slow process of analyzing the data generated in the study described above, and the data for the optimization study completed at the beginning of this quarter continued throughout this quarter. No results are available yet, but they should be available before the end of the next reporting period.

H. Stanford PDP-1 System

1. Hardware

During the first few days of the quarter, the major difficulties with the Kentucky line were resolved. A circuit card found in the 637 unit at Stanford with misaligned edge contacts that did not mesh properly with those in the mounting socket caused intermittant circuit failures.

The central processor interrupt control logic on the PDP-1 was modified to transmit programs from the new multiplex memory system. The original mechanism provided too small a range of memory addresses.

Early in the quarter, an order was placed with Digital Equipment Corporation for a PDP-10 central processor. This unit was delivered to Stanford in late June, and efforts began immediately to interface the processor to the multiplex memory. Limited tests to date indicate that the PDP-10 operated properly.

While the PDP-10 was ordered with most of the central processor optional features, no input/output equipment or core memory was ordered with the machine. More core memory was required, therefore, requests for proposals were issued to a number of manufacturers, many of whom submitted bids in response. Because of their low bid and superior specifications, Ampex Corporation was awarded the contract. The memory has a word length of 37 bits, a cycle time of 900 nanoseconds, and is organized as three independent systems, each containing 32,000 words. Delivery date for the first unit is August 1, 1968, the remaining units should arrive in October. The early delivery of one memory will permit debugging the hardware interface and system software modifications during August. Relatively little effort should be required to add the additional units. Much of the design work on the hardware interface was completed during this quarter.

During June, minor building modifications were completed in the main machine room, and almost all present equipment was rearranged to make space for the new equipment ordered or under construction.

Throughout the quarter, hardware design and software planning proceeded in preparation for the new disk file and the multiple-station digitized audio system. Initial planning and product surveys were directed to the acquisition of high-speed magnetic tape drives and replacement keyboards for the Philco display system.

During June, David Voorhees and Ronald Craven made a site inspection and maintenance tour of the remote installations in Kentucky and Mississippi.

2. Software and Operations

Except for changes to adapt to the new interrupt hardware logic on the PDP-1, few modifications were made to the systems software. The systems staff worked almost entirely on the hardware during this period.

Regular service to most of the schools, except those in Kentucky, which will run for a summer session until August 1, terminated on June 10. Service was also extended for summer school at San Jose from June until August 1.

After the June 10 cut-off, full-scale data reduction and analysis work began on the data from the academic year just finished.

II. Activities Planned for the Next Reporting Period

A. Brentwood Reading Program

The Continuation Project Staff will concentrate on curriculum preparation and the design and development of the hardware and software for the reading teletypewriters. Plans for the fall 1968 operation of the Brentwood Laboratory and procedures for the other seven schools involved in the drill-and-practice program will be discussed with members of the Ravenswood School District administration, Mr. William Rybensky, and the classroom teachers.

A report of the on-going data analysis compiled from the Stanford-Brentwood Reading Project will be included.

B. Drill-and-practice Mathematics Program

The strands program will be expanded to replace the current block-lesson drill-and-practice program. Students in elementary grades will work on the strands program only. The problem-solving program will be considered one of the strands.

College-level students at Tennessee A. & I. will be given a combination of strands and block programs. Extension of the blocks and strands which will include problems appropriate for students in remedial college mathematics courses will begin during the next reporting period.

The problem-solving program will be expanded considerably to include problems for third through sixth grades and beyond. The digits allowed in a number will be increased from the present 6 to 14. This will permit problems using much larger quantities than before (e.g., 2,000-3,000), and should make the problems more challenging. A larger proportion of problems from science will be included in the expanded program.

Extensive examination of the 1967-68 data will begin. Regressions, similar to those presented in past reports, will be run with emphasis on the data from blocks that were not presented to the students during 1966-67. Analyses of variance will be used to determine if the two forms of tests used for pretesting and posttesting for each block were parallel. Several automata will be developed and parameters estimated to determine the correspondence between an automaton and student performance.

C. Logic and Algebra Program

1. The First-year Program

In addition to programming the strategy-help dialogue, curriculum revision of the derivation rule structure, the inclusion of truth diagrams, and the construction of counter-examples will begin. This will necessitate extensive rewriting of materials.

2. The Second-year Program

Curriculum materials will be reorganized and rewritten on the basis of observations and data collected during the year.

3. The Third-year Program

A large portion of the next quarter will also be devoted to dialogue and associated problems. Some work will also be done on simultaneous equations and related geometry.

D. Elementary Russian Program

Revision of our first-year course, including its modification for use with computer-generated audio components, will be completed. We will also complete the remedial block routines which will allow us to generate automatically a vast amount of individualized remedial material correlated with drill sentences and phrases already in the course. The work on the videotapes and analysis of the data will be continued

E. Spelling Program

Data analysis for the several studies finished during the school year will be completed. Related to this effort is the planned write-up of the project, when the final results become available.

It is planned to condense the current computer programs for CBI-Spelling into a demonstration program, so that work on improving the Spelling Driver can continue. Converting this Driver so that it can operate on the new processor (PDP-10) is a planned improvement activity.

F. Stanford PDP-1 System

The installation and software integration work for the new memory systems, the PDP-10 processor, the 2314 disk, and the digitized audio system should be largely completed. There will be a greater emphasis on software development, in addition to the hardware projects now underway.

A decision should be reached on the selection of tape drives and display keyboards. In the case of the keyboards, one or two units may be ordered for extended use-tests before making a final selection.

III. Personnel

With the termination of the Stanford-Brentwood project, it was necessary to release a number of personnel by June 30, 1968. It was possible, however, to absorb certain key personnel in other projects at the Institute.

Logic and Algebra Program. Frederick H. Binford left the Institute to join the faculty at Tennessee A. & I.

Stanford PDP-1 System. Richard Hull resigned from his position as computer programmer.

IV. Dissemination

A. *Publications*

Atkinson, R. C. Computerized instruction and the learning process. *American Psychologist*, 1968, *23*, 225-239.

Atkinson, R. C. Learning to read under computer control. *Programmed Learning and Educational Technology: British Journal of The Association for Programmed Learning*, 1968, *5*, 25-37.

Atkinson, R. C. Priming and the retrieval of names from long-term memory. *Psychonomic Science*, 1968, *11(6)*, 219-220.

Hartley, R. N. An investigation of list types and cues to facilitate initial reading vocabulary acquisition. Technical Report No. 132, May 29, 1968, Psychology Series, Institute for Mathematical Studies in the Social Sciences, Stanford University, Stanford, California.

Mlodnosky, L. B. The Frostig and the Bender Gestalt as predictors of reading achievement. Technical Report No. 129, April 12, 1968, Psychology Series, Institute for Mathematical Studies in the Social Sciences, Stanford University, Stanford, California.

Suppes, P. Computer technology and the future of education. Phi Delta Kappan, 1968, *44*, 420-423.

Suppes, P. Higher-order dimensions in concept identification. *Psychonomic Science*, 1968, *11*, 141-142. (with M. Schlag-Rey)

B. *Lectures*

Anselm, K. Computer-assisted instruction at Stanford: The future of education can be viewed today. Lecture presented at the Educational Media Institute, University of Colorado, Boulder, Colorado, June 24, 1968.

Anselm, K. Educational media specialists in the computer age. Lecture presented at the Educational Media Institute, University of Colorado, Boulder, Colorado, June 25, 1968.

Atkinson, R. C. Series of talks on learning and the educational processes presented at the Institute for Policy Studies, Washington, D. C., April 11-16, 1968.

Atkinson, R. C. Some models for human memory. Lecture presented to the Department of Psychology, University of California, Irvine, California, April 19, 1968.

Atkinson, R. C. Models for human memory. Lecture presented at a psychology colloquium at the University of California, San Diego, California, April 25, 1968.

Atkinson, R. C. Computerized instruction and the learning process. Lecture presented at the NATO Conference, Nice, France, May 13-17, 1968.

Atkinson, R. C. Computerized instruction and the learning process. Lecture presented to the Advisory Board of the Encyclopaedia Britannica Educational Corporation at the University of Denver, Colorado, May 29, 1968.

Atkinson, R. C. Computerized instruction and the learning process. Lecture presented to the Canadian Psychological Association meeting in Calgary, Alberta, June 5-7, 1968.

Atkinson, R. C. Computerized instruction and the learning process. Lecture presented at the Conference on Systems Design for Computer-based Instruction, Snowpass-at-Aspen, Colorado, June 17-18, 1968.

Binford, F. The use of the computer-controlled teletype in teaching arithmetic and logic. Lecture presented to the Institute of Electrical and Electronics Engineers Power Group at the Engineers Club of San Francisco, California, May 14, 1968.

Jerman, M. Computer-assisted instruction in elementary mathematics. Two lectures presented at the Annual Meeting of Department of Elementary-School Principals (NEA), Houston, Texas, April 2, 1968.

Jerman, M. Workshop in Computer-assisted Instruction conducted at Morehead State University, Morehead, Kentucky, April 4-6, 1968.

Jerman, M. An individualized program in elementary mathematics. Lecture given at a meeting of curriculum coordinators and supervisors of the Los Angeles City Schools, Los Angeles, April 17, 1968.

Jerman, M. Communication problems associated with computer-assisted instruction. Lecture presented to telephone company representatives, Lexington, Kentucky, June 18, 1968.

Jerman, M. The Stanford drill-and-practice program. Lecture presented at the Southeast Educational Center, Seattle, Washington, June 26, 1968.

Jerman, M. Computer-assisted instruction in mathematics. Lecture presented at the Workshop in Instructional Improvement, Child Study and Treatment Center, Fort Sleitacoom, Washington, June 27, 1968.

Suppes, P. Can there be a normative philosophy of education. Lecture presented at meeting of The Philosophy of Education Society, Santa Monica, California, April 7, 1968.

Suppes, P. Another look at computer-assisted instruction. Lecture presented at Conference on Technology and Society, Harvard University, Cambridge, Massachusetts, May 2, 1968.

Suppes, P. Problems of using mathematics in the development of the social sciences. Lecture presented at UNESCO Seminar, University of Sydney, Sydney, Australia, May 20, 1968.

Suppes, P. Stochastic models in mathematical learning theory. Lecture presented at UNESCO Seminar, University of Sydney, Sydney, Australia, May 22, 1968.

Suppes, P. Measurement: Problems of theory and application. Lecture presented at UNESCO Seminar, University of Sydney, Sydney, Australia, May 24, 1968.

Suppes, P. The foundations of subjective probability. Lecture presented to the Australian Statistical Society and Australian Mathematical Association, University of Sydney, Sydney, Australia, May 27, 1968.

Suppes, P. Stimulus-response theory of language. Lecture presented to the Department of Philosophy, University of Sydney, Sydney, Australia, May 27, 1968.

Suppes, P. The foundations of subjective probability. Lecture presented to the Department of Statistics, Australian National University, Canberra, Australia, May 29, 1968.

Suppes, P. Research in computer-assisted instruction. John Smyth Memorial Lecture presented at the Victorian Institute of Educational Research, University of Melbourne, Melbourne, Australia, May 30, 1968.

Suppes, P. Models and measurement. Lecture presented to the Department of Psychology, University of Melbourne, Melbourne, Australia, May 30, 1968.

Suppes, P. The foundations of subjective probability. Lecture presented to the Department of Statistics, University of Melbourne, Melbourne, Australia, May 31, 1968.

Suppes, P. "Meet the Author" seminar, New York City School System, June 11, 1968.

Suppes, P. The importance of communications and electronic systems to expand college and university education. Invited lecture presented at IEEE International Conference on Communications, Philadelphia, Pennsylvania, June 12, 1968.

Suppes, P. Working Conference on Systems Design for Computer-based Instruction, Aspen, Colorado, June 17, 1968.

Suppes, P. Using computers to teach elementary mathematics. Invited lecture presented at meeting of National Council of Teachers of Mathematics, Honolulu, Hawaii, June 20, 1968.

Wilson, H. CAI at Stanford. Lecture presented at the Toronto Conference Symposium on Computer-assisted Instruction, Toronto, Canada, April 18, 1968.

Wilson, H. Computer-based instruction in initial reading. Lecture presented at the Conference on Computers in Education, Regina, Saskatchewan, Canada, June 12, 1968.

Wilson, H. CAI, initial preliminary results. Lecture presented at IEEE Conference, Philadelphia, Pennsylvania, June 13, 1968.

C. Visitors

Stanford-Brentwood Laboratory. Visitors to the Laboratory numbered 522. Regularly prescheduled visiting times have been in effect, while special arrangements were made to accommodate large groups of teachers, students, and foreign visitors who could not fit into the regular schedule. Such tours were made available for groups from DeAnza Junior College, members of the San Mateo County Reading Council, and students from San Francisco State College. The breadth of interest in the program continued to increase as the influence and knowledge of CAI is felt in the educational and technical fields.

Each Laboratory visitor spent about one hour viewing the children at the terminal equipment through one-way mirrors and interacting with staff members about the project. During the morning reading program, a special reading demonstration course was available for visitors which gave an explanation with examples of the curriculum. A film of the CAI program that presented an overview of the project and its functions was used for larger groups of visitors.

Drill-and-practice Program. The Drill-and-practice project was visited by 207 persons from April, 1968 through June, 1968. Teachers, students, parents, administrators (from both industry and education), journalists, and engineers were among those persons who observed the project in operation.

Arrangements were made for visitors to observe students at the terminals in a local school and to work through a demonstration lesson themselves. A staff member was present to explain the program and answer questions, supplementing the information given with a printed handout. Occasional tours of the Laboratory containing the computer and auxiliary equipment were also given.

Visitors expressed interest in how the project was administered; the curriculum materials used and their preparation; the system configuration; the response of the children, teachers, and school administrators to the project; and how such a program could be implemented in their local schools.

Elementary Russian Program. A television group from Italy filmed the students at work. Sixty-one visitors interested in computer-assisted instruction viewed the students in action and saw the audio tapes. Most of the visitors took the first lesson of the elementary Russian course.