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Authors

Atkinson, Richard C.

Fletcher, J. D.

Chetin, H. C.

et al.

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THE STANFORD PROJECT

by

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INSTRUCTION IN INITIAL READING UNDER COMPUTER CONTROL: THE STANFORD PROJECT*

R. C. Atkinson, J. D. Fletcher, H. C. Chetin, and C. M. Stauffer

Stanford University
Stanford, California

The low level of reading among a disproportionately large number of Americans is a national problem of the first priority. The problem is not a simple one. And it touches everyone--not only the child falling behind his grade level, or a child's anxious parents and his conscientious but over-taxed teacher. The problem is not confined to the ghetto, to the Appalachians or to the Indian reservations. The periphery of the problem ever widens to include the young person who fails the college entrance exam and the migrant worker whose near illiteracy prevents him from experiencing job and/or economic security.

No one doubts the problem is of national proportions and that it is grave. But can it be solved? Can any mode of teaching be initiated so that children, individually and as a group, maintain a yearly grade level in reading and pass the requirements of the standardized tests used through the school systems? Restated, using the accepted testing methods, how can children be taught reading so that they progress grade by grade and not just "pass through" or "slip by"?

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We not only think the problem can be solved, but believe we have the means to solve it: a computer-assisted instruction (CAI) reading program developed at Stanford University. This particular program has been running for two years in the Ravenswood School District of East Palo Alto, California, and the results indicate that the program could have profound consequences for initial reading instruction throughout the country. Our data have already demonstrated that boys can and do learn to read as quickly as girls. This fact alone is astounding when one considers that it shatters the old education maxim that girls learn to read faster than boys.

What we will describe is not a hypothetical "yes-if-but" program, but a practical, efficient and economical one being used by children in kindergarten through grade three. It is best described as an adjunct to classroom instruction, stressing the decoding aspect of reading and leaving the communication aspect, i.e., reading for meaning, aesthetic empathy, enjoyment, etc., to the teacher.

The Stanford-Brentwood reading program is no new miracle. It has grown out of years of experimentation and research, beginning in 1965 (for further information on earlier research see Atkinson, 1968, and Atkinson and Wilson, 1968) and today including programs in reading, mathematics, spelling drill, Russian, logic and Boolean algebra, and a program teaching computer programming. New programs recently implemented include language arts, remedial English for junior high school, and language-arts for handicapped children. More than 3,000 students, from kindergarten to university, receive daily instruction from a central computer housed at Stanford University. Telephone wires have provided the connections from the computer to student terminal devices as far away as Washington, D. C.

Space does not permit us to give a comprehensive review of our previous research, nor is it feasible to review the important research done in recent years by psychologists and educators concerned with the reading problem. In essence, all theories about the teaching of reading face the problem: how to teach reading so that the children move along, not lock-step, but as individuals, unique and separate, yet advance with their group to become literate adults.

Rationale

In the development of a computer-based curriculum for initial reading, a number of operational assumptions were made that should be explicated. The reading staff assumed, along with Bloomfield (1942), Carroll (1964), Fries (1963), and others, that two major aspects of reading are communication (reading for meaning, aesthetic empathy, enjoyment, etc.) and decoding. The communication aspect of reading seemed best presented in the classroom by a human teacher in some sort of dialogue mode, and the decoding aspect of reading seemed best presented by a computer in a consistent drill or practice mode. The major emphasis of this curriculum, then, is on reading as decoding.

Decoding may be defined as the rapid, if not automatic, association of phonemes or phoneme groups with their graphic representations; for example, the association of the phoneme /æb/ with its graphic shape (or grapheme) ab, or the association of the phoneme /eyb/ with its graphic representation abe. It was assumed, therefore, that (a) learning to read necessitates learning a large repertoire of these "grapheme-phoneme" associations; or that (b) learning to read is significantly facilitated by acquiring a large number of these associations. Together with Fries (1963) and Ruddell (1966), the staff decided that it would be worthwhile to teach reading as decoding to initial readers.

Further assumptions were made about the appropriateness of computer-based presentation. Fries (1963, p. 132) stated that learning to make grapheme-phoneme associations was not only necessary for those learning to read, but that these associations must become habits so automatic that the graphic shapes themselves sink below the threshold of attention. An effective way for these associations to become automatic is by repetitive presentations for short intensive drill periods with the students given immediate knowledge of results after each of their responses. Such drill can be accomplished effectively at this time by an individualized computer-assisted drill program.

Since the emphasis in this program is on the regular grapheme-phoneme correspondences (or "spelling patterns") of English, the curriculum can be considered an appropriate adjunct to any classroom initial reading series. The initial curriculum, prepared in the fall of 1968, was closely linked to the three basal reading texts then being used in the district's primary classrooms and was programmed as three separate series. The Stanford reading curriculum currently used is a carefully constructed program based on the most frequently used vocabulary in major reading texts and sight-word lists which were scanned by utility computer programs for common occurrences and order of introduction.

Individualization of Instruction

In teaching reading there are many factors to be considered and many variables that can be manipulated. For instance, we can experiment with such things as the presentation of the alphabet--which letters should be presented first to avoid sound and sight confusion yet allow for early grouping to form words for phonetic and graphic instruction. In the end, however, the overall effect of these manipulations are small compared to one single and outstanding aspect of CAI instruction: individualization.

Individualization, then, is the over-riding consideration. Granted that one can manipulate the curriculum and even manipulate the children in a teaching mode. These strategies become insignificant, however, if the instruction is not suited on a moment-to-moment basis to the child's needs and abilities. Computer-assisted instruction provides an answer. As the results of CAI instruction become more substantiated through testing and data collection, it does not seem too preposterous to contend that the idealized Greek tutorial system of the one-to-one basis of the tutor-student (the tutor here being the teacher plus CAI) is closer to being realized today than it has for centuries.

Computer-assisted instruction as a research tool has been around for years and has had its share of problems. It is encouraging to note, however, that the pessimism surrounding two aspects of CAI--cost and depersonalization--is beginning to dissipate. We would like to say a few words about each of these aspects.

From the beginning, most people involved with CAI have been realistic about its high costs. Nevertheless, people were optimistic and felt that as equipment design became more standardized and production methods more efficient, the cost would be less. These reductions in cost have, in fact, taken place. Also, in the beginning, many of us believed that the more hardware employed the better, and there was an abundance of expensive innovations. It has become increasingly obvious that some very sophisticated teaching strategies can be implemented using quite simple and inexpensive equipment. Some of the original, complex and expensive tools have passed on while some, in more perfected forms, have been incorporated into CAI instruction as useful, instructive aids to CAI.

For our own part, we have found that simplicity has been the answer. The easily operated Model 33 teletypes are ideal for both experimental and pedagogical purposes. Even the youngest school child quickly learns to type on the keyboard--in fact, the child learns with an ease contrary to everyone's expectations. Added to the teletype is a headphone jack with a small-gain amplifier that conveys a vocabulary of some 5,000 words. The cost of a daily 12-minute session per student is about 40¢--and even that figure could be reduced if the system were dedicated to a reading program only. What does 40¢ per child per day mean? Given the actual number of 176 days a child is in school, it doesn't take long to calculate 40¢ x 176 days = $70. Consider that we are saying that for as little as $210 a child can maintain grade level in those three initial and, what we consider, crucial years of his reading instruction.

Let us turn now to the subject of depersonalization. There are those who consider that the widespread use of CAI will contribute to the gross depersonalization so often predicted for our highly technological, densely populated society. We feel that the opposite is closer to the truth. The kind of individualized instruction CAI can offer assists a child through rapid acquisition of reading skills to enlarge his literate comprehension of his environment and his self.

A description of a contemporary classroom and the role of CAI to assist the teacher might help to demonstrate what we mean as a rebuttal to the depersonalization theory. Let us observe a hypothetical class. First, look at the clock. If the time is between 8 a.m. and 8 p.m., you may be sure somewhere in our fifty states what we describe is taking place.

A teacher is instructing her class of thirty or more in, say, spelling for a 15- or 20-minute period. She uses chalk and blackboard, pencil and paper, as do her charges. Although she explains what she writes, and often has the students repeat her examples, she is unable, of course, to determine each child's comprehension level. Some days she saves a portion of the time for a test drill. The children take paper and pencil and she dictates the spelling words. While doing this, she may stroll up and down the aisles and observe here and there the children's responses. She prefers not to interrupt the entire class to point out individual errors. After the test, she relies on conventional modes of correcting mistakes: the children may correct each other's papers, or their own, or the teacher may collect the papers, correct and return them to the children after a few days.

Keeping in mind such factors as time lapse between instruction and testing, between testing and reviewing, and not forgetting the ratio of one teacher to thirty or more students, it would seem that the students' language learning mode and the reinforcement of their learning, leaves much to be desired. Besides, what's to keep the children from gazing out of the window or simply phasing out of spelling drill altogether? And are we not presumptuous to expect one human being to understand the unique problems of thirty or more children let alone differentiate, instruct and reinforce the learning of each individual student? Yet, we are presuming just that when our voices join the chorus of, "Why aren't our children learning to read?"

We have not digressed from the matter of depersonalization. Overcrowded classrooms and overworked teachers are the ingredients of depersonalization. What we are suggesting as a counter measure is CAI; in other words, individualized instruction for a brief period each day on a reading program designed to accommodate individuals according to their unique needs.

For a moment, let us return to the classroom we have just viewed. Suppose at different times during the school day a different portion of the class was excused to attend CAI. Experience has shown us that the children look forward to these sessions. In a recent survey the children participating in the CAI reading program were asked to rate the program on a 1 to 5 scale. Fifty percent of the students gave it top rating; 25 percent gave it the second rating which was that they liked the program; of the remaining 25 percent, only 5 percent said they did not like it while 10 percent said, "It's okay but I'd rather be outside playing!"; and the remaining 10 percent had no opinion.

Interestingly enough, those students less advanced than their peers were among the most enthusiastic. This is seldom the case in a classroom milieu where those students who lag behind the group are often painfully self-conscious of this fact. Let us note that a computer never "puts a student down" for a wrong answer or, no matter how foolish his answer might seem or how often he is wrong exposes him to the slightest form of ridicule.

Initially, the student sits down to the teletype, adjusts his head set, and "signs on." Each student types R (for reading), his number, and his first name. At once the program responds by typing his last name. When the child signals that the name is correct by typing the space bar, the program begins at the point where the child terminated his previous session.

Or, if it is the child's first time at a teletype terminal, which can be any day of any week of the school year, a proctor or teacher's aide assists the child in getting acquainted with the procedures. The first strand (strand is the term used to designate a component part of the initial reading program) is called the Reading Readiness Strand. On the teletype paper or printout, the child receives typed messages that are more fully explained by the audio. After the program has rehearsed the student in the sign-on procedure, the format for the Reading Readiness Strand looks like this:

	Display on the Printout	(Audio)
		(Welcome to reading)
	Type your number and name	
The student responds by typing:	R213 JOH	
		(Type N)
The student responds by typing:	R213 JOHM	
		(No, you typed M)
The program prints:	N	(We wanted N)
The program prints:	R213 JOH	(Type N)
The student responds by typing N after R213 JOH	R213 JOHN	
		(Good)
The program prints John's last name:	R213 JOHN SMITH	
The program now proceeds to the point in the lesson where John last terminated.		

The teletype repositions after each response. When John is correct in his response, he receives from time to time an audio message such as "good," "great," or another positively reinforcing message before the program proceeds to the next exercise.

The Reading Readiness Strand covers all the aspects of the sign-on procedure and attempts to teach the manual skills required to interact with the program. Following the terminal orientation section, the Reading Readiness Strand attempts to teach a student to sign himself on the program without proctor supervision. To leave the Reading Readiness Strand and enter the next strand--the Letter Identification Strand--a student must perform the sign-on procedure with no more than one error. This strand differs from all others in that branching from it is criterion dependent rather than time dependent.

After describing the curriculum strands, we will explain how a teacher can use the computer to call up a class report or an individual student's report. She is never more than a few moments away from evaluating the class or examining the individual child's lessons and knowing the area in which the child is experiencing the greatest degree of difficulty. The printout, although it does not give grades or percentages as it was our intention to keep this an "ungraded" program, gives all the pertinent information a teacher needs to see where a student is making progress and where he is having difficulty.

The program is divided into seven strands: 0 - Reading Readiness; I - Letter Identification; II - Sight-Word Vocabulary; III - Spelling Patterns; IV - Phonics; V - Comprehension; VI - Language Arts. In Figure 1 the strands are represented by horizontal lines and the sections within a strand are represented by dots on the lines. The vertical arrows indicate at which point in one strand a student moves to another strand.

Students move through each strand in a roughly linear fashion. Branching or progress within strands is criterion dependent; a student proceeds to a new exercise within a strand only after he has attained some (individually specifiable) performance criterion in his current exercise. Branching between the strands is time dependent; a student

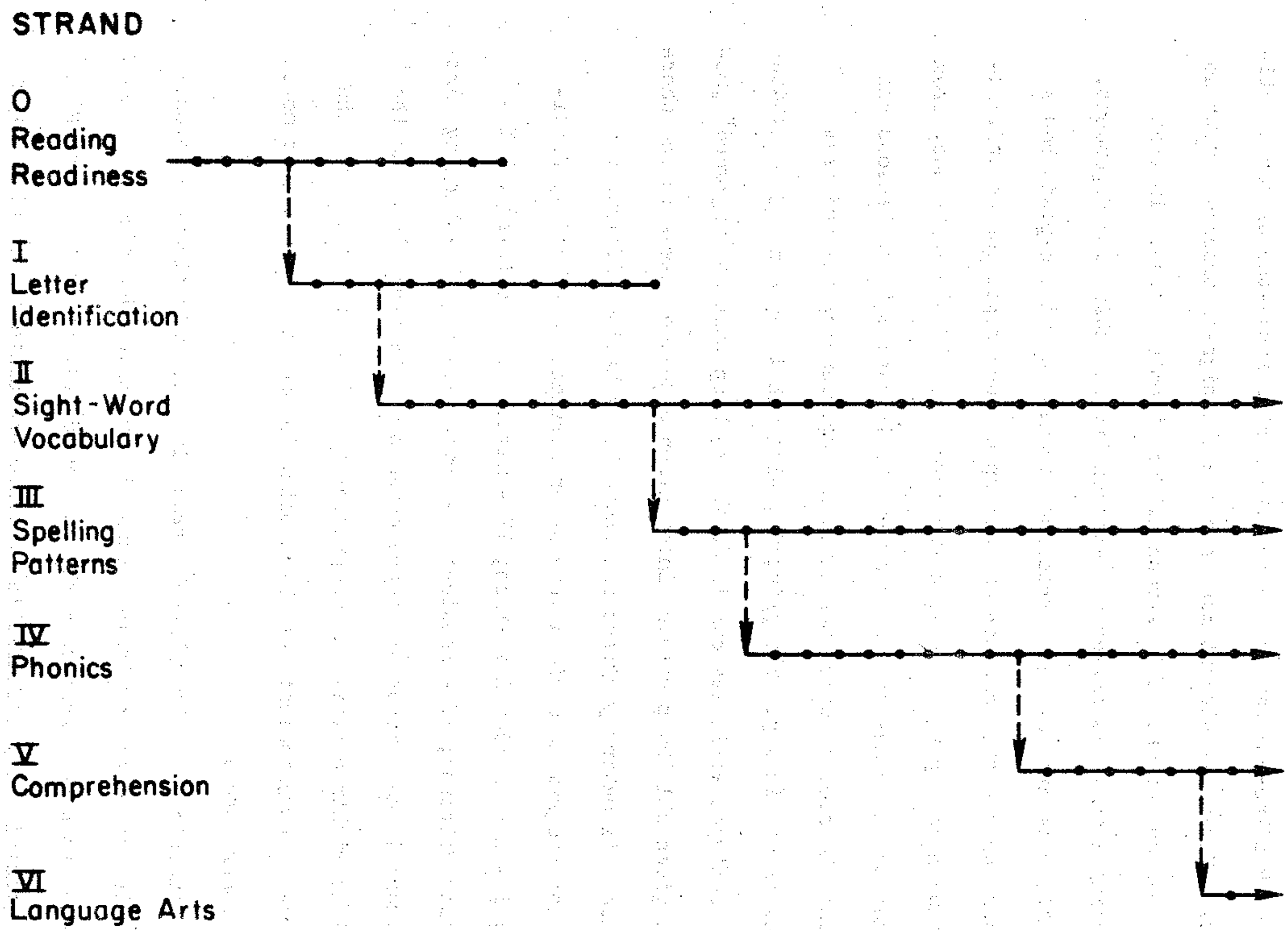

Figure 1. Flow Diagram of

the Reading Curriculum

moves from one strand to take up where he left off in another after a certain (again, individually specifiable) amount of time regardless of what criterion levels he has reached in the strands. Within each strand there are progressively more difficult exercises that are designed to bring students to fairly high levels of performance. The criteria can easily be changed and research studies are currently underway investigating alternative procedures.

Entry into each strand is dependent upon a student's performance in earlier strands. For example, the Letter Identification Strand starts with a subset of letters used in the earliest sight words. When a student reaches a point in the Letter Identification Strand where he has exhibited mastery over the set of letters used in the first key words of the Sight-Word Vocabulary Strand, he enters the Sight-Word Vocabulary Strand. Entry into both the Spelling Patterns and the Phonics Strands is controlled by the student's placement in the Sight-Word Vocabulary Strand. A student may work in several strands simultaneously. Once he enters a strand, however, his advancement within that strand is independent of his progress in other strands.

Currently most students spend two minutes in each strand and their daily sessions are eight or twelve minutes. Although the time each student spends in any strand and the length of the daily drill sessions are parameters that may be uniquely specified for individual students or particular classes, a student may be stopped at any point in an exercise either by the maximum-time rule for the strand or by the session-time limit. However, sufficient information is saved in his record to assure continuation from precisely the same point in the exercise when that strand is next encountered.

The alternative approaches to time on strands and time on the system allow the program to be manipulated so that a "common front" can be maintained both for the classroom as a whole and for the individual student's within-strand rate of progress. Table 1 illustrates the various combinations possible in adapting the reading program to classroom and/or individual needs.

Time per Strand	Time on the System: Fixed	Time on the System: Variable
Fixed	I	II
Variable	III	IV

Table 1

Time on both the system and time per strand can be either fixed or variable. For instance, a student or class can be set to run for a specific number of minutes each day; or, if some student(s) is behind the class, he can be allowed to run for a longer period of time on the system so that he catches up to the strand sections where most of his class is working.

The time the students spend on each strand can also be fixed at a particular number of minutes per strand, or varied so that if a student's performance in one strand is not on a par with the rest of the class and he is lagging behind in that strand, the time he spends on the strand can be varied so that he remains on that strand for longer periods of time or until he is working at a more uniform level through all the strands. For example, if a child who spends twelve minutes on the system with equal times of three minutes on each of the four strands he is working on, is found by his teacher to be lagging far behind in one strand, his teacher can ask the program to increase his time on that particular strand to, say, six minutes and distribute the remaining six minutes among the other three strands.

The strands are comprised of sections of curriculum items, and it is in these sections that a student must reach criterion before progressing in the strands. Each section is presented in separate exercises. In each exercise the items of the section are presented in random order until the student has achieved a criterion. A student who already knows the material may leave the exercise after as little time as 30 seconds.

Students receive instruction for the exercises by means of digitized audio messages. A vocabulary of approximately 5,000 sounds has been recorded and stored in digital form on the computer's magnetic disk. The student inputs his responses on the teletype keyboard. When he has completed his response, he presses the space bar which returns control of the terminal to the computer for response evaluation. If the student discovers an error in his response, he may press the rubout key before pressing the space bar and the entire problem will be presented again for a second trial. If a student presses the rubout key too many times before entering a response, he receives a "too many rubouts" message. The student has a printed record of the work completed at the end of his session. As mentioned above, first-grade children adapt quickly to using the keyboard and have no difficulty in typing the relatively short responses required.

Originally, the curriculum preparation adhered strictly to the vocabulary appearing in the basal texts used in the Ravenswood School District's primary reading program. In its revised (1969) form, the Stanford reading program consists of a curriculum that complements any classroom initial reading series. Word lists were assembled from major basic reading texts as well as recognized sight-word lists. Using utility programs on the computer, these lists were compared and screened for common occurrence and order of introduction. The resulting list provided the basis for the vocabulary and spelling pattern strands.

This revised list of words used in the reading program was placed on a disk memory file. Each word in the file is described by four numbers that indicate the book and page number of first occurrence in an initial reading series. A computer program can be used to construct sublists of words stored on the disk file. For example, it is possible to have a list of all words in the series ending in -in in order of first occurrence. Existing programs written by staff members for other purposes can be adapted to accomplish this with little difficulty. With one dictionary, it will be possible to construct other dictionaries using different descriptive numbers.

Description of the Strands

Strand O - Reading Readiness. Readiness materials, designed both for the classroom and at the CAI terminal location, acquaint the student with the system and teach him the manual skills required to interact with the program. The Reading Readiness Strand progresses through three stages over a three- to five-day period: the Free Keyboard, the Controlled Keyboard, and the Student's Name and Number. The first stage, the Free Keyboard, is designed to familiarize students with the letter keys and the space bar. The program responds to any graphic the student types.

	Display on the Printout	(Audio)
		(Type any key.)
The student responds by typing:	T	(Now type the space bar.)
The student responds by typing the space bar:		(Look at the printout. You typed T.)
		(Type any key.)
The student responds by typing:	F	(Now type the space bar.)
The student responds by typing the space bar:		(Good. Look at the printout. You typed F.)
		(Type any key and then the space bar.)
The student responds by typing: and the space bar:	3	(Look at the printout. You typed 3.)

The second stage of the Reading Readiness Strand is the Controlled Keyboard. The student, after instruction on typing the letter S for "same" and D for "different," is asked to type either S or D when presented with a group of letters arranged as a discrimination exercise.

	Display on the Printout	(Audio)
The program prints:	M M M	(Look at the letters. Type S for same, type D for different.)
The student responds by typing:	S	(Yes, they are the same.)
The program prints:	M W M	(Look at the letters. Type S for same, type D for different.)
The student responds by typing:	S	
The program prints:	////	(No. They are different.)
The program prints:	W M M	(Look at the letters. Are the letters the same? Type S for same, Type D for different.)
The student responds by typing:	D	(Good, they are different.)

When the student has completed the discrimination exercises on the Controlled Keyboard section of the strand, he moves on to stage three of the Reading Readiness Strand where he is taught to sign-on by typing his name and number. First, the student is instructed in the typing of the letters in his first name. When he has mastered those letters, he is taught the digits in his assigned number. These are the numbers and letters he must use each time he signs on the program.

	Display on the Printout		(Audio)
The program prints:	F		(Type F.)
The student responds by typing:	F		(Good.)
The program prints:		F---	
The program prints:	R		(Type R.)
The student responds by typing:	R		(Great!)
The program prints:		FR--	
The program prints:	E		(Type E.)
The student responds by typing:	E		
The program prints:		FRE-	
The program prints:	D		(Type D.)
The student responds by typing:	D		(Good.)
The program prints:		FRED	(Let's type your name again.)

When the student has met criteria on the letters in his first name and the digits of his student number, he is instructed in the actual sign-on procedure. The program prints PLEASE TYPE YOUR NUMBER AND NAME, and the student is led through each step of the sign-on procedure, receiving as he types appropriate audio messages. When he has met criteria on the sign-on procedure, he is branched into Strand I - Letter Identification.

Strand I - Letter Identification. The sequence of letters introduced in this strand is determined by the sight-word vocabulary in the early sections of Strand II. Each letter is presented twice in the Letter Strand. For the first pass through the alphabet, grouping of letters in sections was designed to minimize visual confusion. For the second pass through the alphabet, grouping was designed to maximize confusion. In all cases, sections were designed to minimize auditory confusion.

Three exercises are used throughout the Letter Identification Strand. In the first exercise, a letter is typed on the printout and the student is requested to type the same letter.

Exercise 1	Display on the Printout		(Audio)
The program prints:	T		(Type T.)
The student responds by typing:	T		
The program prints:		YES	
The program prints:	R		(Type R.)
The student responds by typing:	R		
The program prints:		YES	(Good.)
The program prints:	M		(Type M.)
The student responds by typing:	N		
The program prints:		//// M	(No, we wanted M. Type M.)
The student responds by typing:	M		
The program prints:		YES	(Good.)

The exercise is repeated for still another letter. Random presentation of letters in a section continues until the student reaches criterion for the first exercise, at which time he is advanced to the next exercise in the Letter Identification Strand. The criterion procedure is either all correct on the first pass through the section or two consecutive correct answers for each item.

Exercise 2	Display on the Printout	(Audio)
The program prints:	R S T	(Type R.)
The student responds by typing:	R	
The program prints:	YES	(Great!)
The program prints:	S R T	(Type T.)
The student responds by typing:	T	
The program prints:	YES	

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

Exercise 3	Display on the Printout	(Audio)
		(Type S.)
The student responds by typing:	S	
The program prints:	YES	
		(Type R.)
The student responds by typing:	R	
The program prints:	YES	
		(Type T.)
The student responds by typing:	E	
The program prints:	//// T	(No. Type T.)
The student responds by typing:	T	
The program prints:	YES	

When the student achieves criterion on the letters in the section, he proceeds to the second set of letters.

Throughout the curriculum, if the student responds correctly, he proceeds to the next presentation. If he responds incorrectly or exceeds the time allowed for a response, the teletype displays the correct response and moves to the next presentation.

When the student responds correctly, he receives randomly scheduled audio reinforcement messages. In the beginning stages of program development, these reinforcement messages consisted of a few commonly used positive words, but as the dictionary has been enlarged and more flexible utility programs written, it has become possible to include a greater variety of expressions. Programs now have reinforcement messages with words appropriate to season and locale, and jargon familiar to the children.

When a student meets criterion on a specific number of letters (i.e., those required for the first words in the sight-word vocabulary of Strand II), he begins Strand II. At this point, he works simultaneously in both Strands I and II, but at different levels of difficulty within each strand.

Strand II - Sight-Word Vocabulary. Strand II provides practice on a vocabulary that is introduced and taught in the classroom and contains words common to the major basal reading texts. While the classroom teacher introduces and teaches each word with both content and picture cues, the teletype provides concentrated drill on the word itself. Experience has indicated the usefulness of picture and content cues as well as the usefulness of repeated drill on the printed word itself.

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

Exercise 1	Display on the Printout		(Audio)
The program prints:	PEN		(Type pen.)
The student responds by typing:	PEN		
The program prints:		YES	
The program prints:	NET		(Good. Type net.)
The student responds by typing:	NET		
The program prints:		YES	
The program prints:	EGG		(Great. Type egg.)
The student responds by typing:	EFF		
The program prints:		//// EGG	(No. Egg.)
The program prints:	NET		(Type net.)
The student responds by typing:	NET		
The program prints:		YES	
The program prints:	EGG		(Type egg.)
The student responds by typing:	EGG		
The program prints:		YES	

When the student has achieved criterion for each of the words forming the section, he begins Exercise 2:

Exercise 2	Display on the Printout	(Audio)
The program prints:	PEN NET EGG	(Type pen.)
The student responds by typing:	PEN	
The program prints:	YES	
The program prints:	NET PEN EGG	(Type net.)
The student responds by typing:	NET	
The program prints:	YES	

As in Exercise 2 of the Letter Identification Strand, the order of the items which comprise the teletype display is random for each presentation. When the student has met criterion for each new word in each of the two exercises, he proceeds to the next section of words and begins again on Exercise 1.

Remember that the student must meet criterion or exhibit mastery in each of the exercises over all the words in the section before he can proceed to the next section.

Strand III - Spelling Patterns. The Spelling Patterns Strand is designed to provide direct and explicit practice with English spelling patterns and emphasizes the regular grapheme-phoneme correspondences that occur in the graphic representation of English. The spelling patterns presented in this strand will be presented in the Phonics Strand that follows. However, different words, unique to the Phonics Strand, are used in that strand.

The following exercises are used in the Spelling Patterns Strand:

Exercise 1	Display on the Printout	(Audio)
The program prints:	SLEPT KEPT CREPT	(Type crept.)
When the student does not respond within the set time, the program prints TIME and the correct response.	TIME CREPT	
The program prints:	KEPT SLEPT CREPT	(Type kept.)
The student responds by typing:	KEPT	
The program prints:	YES	
The program prints:	CREPT KEPT SLEPT	(Type slept.)
The student responds by typing:	SLEPT	
The program prints:	YES	(Good.)

Exercise 2	Display on the Printout	(Audio)
		(Type kept.)
The student responds by typing:	KEPT	
The program prints:	YES	(Fantastic. Type slept.)
The student responds by typing:	SLEPT	
The program prints:	YES	(Fabulous. Type crept.)
The student responds by typing:	CREPT	
The program prints:	YES	(Great!)

Sections for this strand consist of a set of monosyllabic words, such as kept, slept, crept. These words embody the same spelling pattern, <u>ept</u>, which in each of these words corresponds to the same phoneme, /ept/.

Strand IV - Phonics. When the student has shown a mastery of a specified number of words in the Spelling Strand by completing a predetermined number of sections in that strand, he begins Strand IV with drill in phonics.

Again, we wish to emphasize that each strand is separate from every other strand although strands are related. For example, entry into Strand III is dependent on the student's progress in Strand II. Once a student enters a strand, he is allowed to proceed at a rate commensurate with his ability.

Exercises in the Phonics Strand concentrate on initial and final consonants and medial vowels. A departure is made, however, from traditional phonics exercises in that the students are never required to rehearse or identify consonant or vowel sounds in isolation. The smallest unit of presentation is a dyad, i.e., a single vowel-consonant or consonant-vowel combination.

The following exercises are used in Strand IV:

Final Consonant Exercise 1	Display on the Printout	(Audio)
The program prints:	-IN -IT -IG	(Type /IG/ as in fig.)
The student responds by typing:	IG	
The program prints:	YES	
The program prints:	-IT -IN -IG	(Good. Type /IT/ as in fit.)
The student responds by typing:	IT	
The program prints:	YES	

Exercise 1 (Continued)	Display on the Printout	(Audio)
The program prints:	-IG -IN -IT	(Type /IN/ as in pumpkin.)
The student responds by typing:	IN	
The program prints:	YES	(Fabulous.)

In Exercise 2, the student types the full word. An example of Exercise 2 for the initial consonants is as follows:

Exercise 2	Display on the Printout	(Audio)
The program prints:	DA- MA- HA- --D	(Type mad.)
The student responds by typing:	MAD	
The program prints:	YES	(Great!)
The program prints:	HA- DA- MA- --M	(Type ham.)
The student responds by typing:	MAM	
The program prints:	////HAM	(No. We wanted ham.)
The program prints:	DA- HA- MA- --D	(Type dad.)
The student responds by typing:	DAD	
The program prints:	YES	(Good.)
The program prints:	MA- DA- HA- --LF	(Type half.)
The student responds by typing:	HAT	
The program prints:	////HALF	(No. We wanted half.)
The program prints:	HA- MA- DA- --D	(Type mad.)
The student responds by typing:	MAD	

As in Strands I and II, the student works with a section of specified units. The student must meet criterion for each set of dyads in the exercise before proceeding to the next set.

The audio reinforces the sound values with randomly selected examples from a matrix of three sample words--two monosyllabic and as often as possible an easily identifiable polysyllabic word. However, the word to be typed by the student is always taken from the two monosyllabic exemplars.

Strand V - Comprehension. When the student has met criterion over a specified number of Strand IV sections, he enters Strand V. Strand V provides practice on the meaning of the words introduced in the classroom and mastered by the student in the Sight-Word Strand. The exercises are of two types: 1) categorization, and 2) phrase and sentence completion. A section in the first exercise consists of three groups of three words. Each word is associated with one of several categories. The presentation consists of a display of three words followed by a request to type the word of a particular category. Here is an example:

Exercise 1	Display on the Printout	(Audio)
The program prints:	EGG MAN TAN	(Type the word that is a color.)
The student responds by typing:	TIN	
The program prints:	////TAN	(No, tan is a color.)
The program prints:	ON DOG RUN	(Type the word that is something you can do.)
The student responds by typing:	RUN	(Good.)

Exercise 1 (Continued)	Display on the Printout	(Audio)
The program prints:	FARM TART HAND	(Type the word that is a place.)
The student responds by typing:	FARM	
The program prints:	DOG RUN ON	(Type the word that tells where.)
The student responds by typing:	RUN	
The program prints:	////ON	(No, on is the word that tells where.)

The order of the three words presented is random and the target word, with its associated category, is randomly chosen from the displayed words. If the program selects "tan" as the target word, the audio requests, "Type the word that is a color," Associated with each word is an audio request to identify it. When the student has met criterion in a section of words, he proceeds to Exercise 2.

The second exercise consists of a section of three sentences (or phrases) with one word missing in each. Displayed with each sentence are three words--two are distractors and one correctly completes the sentence. One of the distractors is of the correct form class, but is either semantically or syntactically unacceptable in that it breaks a subcategorization rule. The second distractor is unacceptable both semantically and syntactically. The format of this exercise is as follows:

Exercise 2	Display on the Printout		(Audio)
The program prints:	THE --- RAN FAST.		
		RED COT RAT	(Type the word that correctly completes the sentence.)
The student responds by typing:	RAT		
The program prints:		YES	(Good.)
The program prints:	TOM PUTS ON HIS ---.		
		STOP PIG HAT	(Type the word that correctly completes the sentence.)
The student responds by typing:	STOP		
The program prints:		////HAT	(No. Tom puts on his hat.)
The program prints:	YOU CAN PET A ---.		
		DROP CAT RESTS	(Type the word that correctly completes the sentence.)
The student responds by typing:	CAT		
The program prints:		YES	(Good.)

When the response is incorrect, the audio repeats the completed sentence correctly. When the student has reached criterion on the exercise and reaches a specified point within the strand, he will enter the Language Arts Strand.

Strand VI - Language Arts. Strand IV, which is to be implemented in the near future, is a strand dealing with particular skills in language arts. The strand's exercises are designed to initiate a conscious mastery of the mechanics of sentence structure. From the broad spectrum of skills involved in language arts, the reading staff chose to place special emphasis on those areas identified as particularly troublesome for handicapped children as well as children from depressed environments. Practice will be provided in a number of areas including: (1) English idioms that are often misused; (2) endings and order of modifiers; (3) tense agreement with intention of building a repertoire of tenses; (4) proper use of auxiliary verbs. The format of the exercises will be similar to those in the preceding strands.

Digitized Audio

Digitized audio refers to a complex conversion process unlike the familiar reproduction of sound via phonograph or tape recorder. These latter mechanisms are analog devices, i.e., devices which store and reproduce continuous information. Digital computers handle discrete units of information. Speech waves are analog (continuous) information, and must be converted to digital form for storage by digital computers and reconverted to analog form for reproduction.

The analog-digital conversation for storage is performed by "sampling" the speech wave, i.e., breaking it up ("chopping it") into a series of digits that indicate whether the wave is higher or lower at given points. Analog-digital conversion is presently done in two stages. The original speech wave can either be live or tape recorded--at present all input to the Stanford system is live. First a program receives the original wave filtered through a "band pass" that selects only certain sound frequencies (500-2500) to adapt the sound wave to telephone line conditions. This program samples ("chops up") the wave 6,000 times a second, assigning a digit between 0 and 63 to each sample (i.e., 6 bit resolution). A second program takes this temporarily stored output and samples 36,000 times a second, assigning either 1 or 0 ("up" or "down")--i.e., 1 bit resolution at 36 kc. This final digital output is stored on an IBM disk (the digital equivalent of a phonograph record).

The digital-analog conversion process takes place during "run time," i.e., as students operate on the system. The call for a given audio message by the instructional program directs the computer to bring the appropriate block of digital information from the 2314 disk to one of the 2 k (2,048-computer-word) audio buffers in core memory. From core the digits are fed to the multiplexer, which assigns them to one of 40 station shift registers that control the 40 audio units at student terminals. Before leaving Stanford via individual telephone lines, these audio digits pass through DAC's (digital-to-analog converters). A two-part amplification system at each of the schools picks up the analog information and feeds it to the headset at each terminal. One amplifier, adjustable by proctors, controls minimum volume for all terminals, while terminal amplifiers can be adjusted by individual students.

Figure 2 shows a chart that indicates the major steps in the process described above.

Scheduling

An important factor in any teaching innovation is the cooperation and enthusiasm of the classroom teacher. Often her approach determines the attitude of the student. As we look to the teacher for originality, creativity and depth of presentation, so too the teacher should look to

Diagram of Analog-Digital-Analog Process

CAI Reading Program

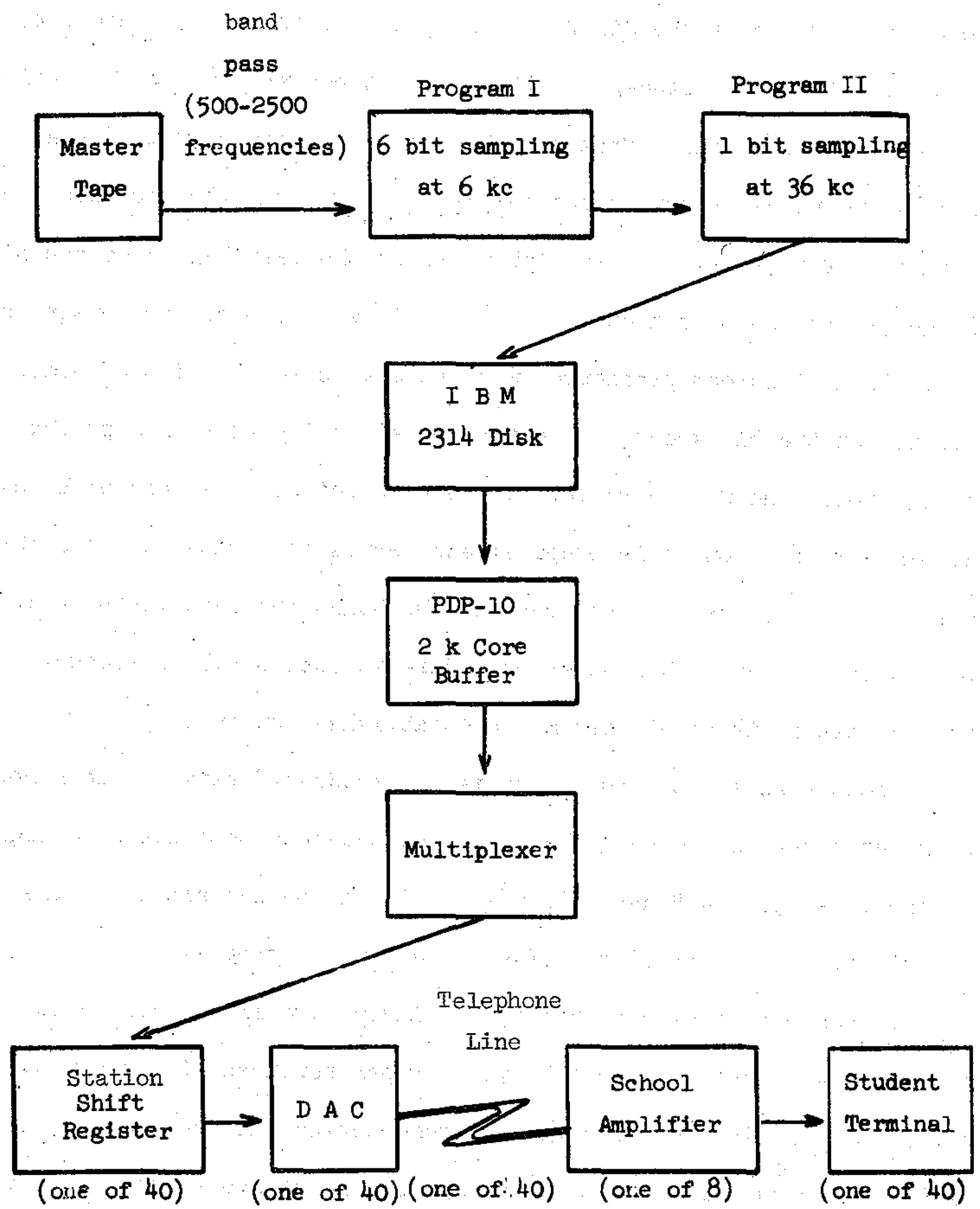

Figure 2

CAI as a reliable tool to speed and smooth the learning process, freeing her to go beyond the more routine essentials in the classroom.

Once scheduling arrangements have been made with the principal and the director of the CAI facilities, a regular routine should be established for the students. If the teletypes are in another building or a great distance from the classroom, a teacher's aide or an older student can escort young children to and from the location. Where a number of terminals are available, as in the East Palo Alto school, large groups can be scheduled. In schools with one or two terminals, individual classroom procedures must be developed. A list of names written on the blackboard indicating order of departure has proved successful. The name-card method can also be used. A card with several names written on it is prepared and serves as a pass to leave the classroom. When the student returns, he hands the card to the next person on the card. Whichever procedure is chosen by the teacher for her class, it should become an established routine.

Another aspect of scheduling is the trade-off between the number of minutes per session and the number of students that can be assigned to the teletypes each day. This schedule can be set either at the individual student or at the class level by the program.

It has been observed that the children have little difficulty in learning to operate the teletype. Paper replicas of the keyboard give students classroom practice in remembering the location of the letters. Using her intimate knowledge of the students, the teacher can determine how much classroom preparation is necessary. It has been our experience that after the students receive an explanation of the program and then the Reading Readiness Strand which acquaints them with sign-on procedures, they receive great pleasure in their individual accomplishments on the teletypes.

Teacher Reports

Efforts have been made to keep this an ungraded program. Although marks exist in a Curriculum Guide to indicate specific levels for comparison or referral by the teacher, no indication is made on the student's printout of score, percentages or grades. There is only a listing of accumulated time on the program, the date, and the section numbers for each strand on which a student is working. Both primary students working at grade level and remedial students proceed through the program at their individual rates of speed.

The length of a daily reading lesson is twelve minutes, which appears to be an ideal time period for primary students. This time parameter can be adjust should there be such a need.

A complete status report for an entire class is available to a teacher at any time. An example of this report appears in Figure 3. When a status report is requested--which can be any time from any student terminal--and the program given a class number, a utility routine prints the date, total number of students in the class, and the name of the teacher. Then the program goes on to list, in this order and for each student who has signed on to the reading program, the number of minutes accumulated in the program, the section number of the curriculum items he is working on in each strand, a plus if he was on the program that day, his identification number, and his

CLASS 182 MRS. BRESLIN 7 JAN 70
31 STUDENTS -- BRENTWOOD SCHOOL

READING REPORT -- TYPES + IF RUN TODAY

MIN	L	W	PH	SP	CC	CS			
61.3	6	1	0	0	0	0	+	3023	ANDRE JONES
66.3	17	9	4	4	0	0	+	3232	VIZAR BALCITA
46.6	10	7	2	0	0	0		3233	JEROME BRADFORD
63.8	15	10	4	1	0	0	+	3234	NATHANIEL CHRISTOR
28.1	8	5	1	0	0	0		3235	VERONICA CROWELL
43.0	8	4	0	0	0	0	+	3236	RICO CONTERO
57.2	14	7	2	0	0	0		3237	LINDA FRANCOIS
77.0	15	11	3	2	0	0	+	3238	ALFRED FRAZIER
55.8	11	8	2	0	0	0		3239	RAMON GIL
49.2	13	7	2	0	0	0		3240	KRYSTAL GRIFFIN
56.8	13	5	1	0	0	0	+	3241	MARCUS HENDERSON
23.7	7	3	0	0	0	0		3242	FELITA BARRIES
72.9	16	9	2	0	0	0	+	3243	DWAYNE HOBBS
71.2	14	9	1	0	0	0	+	3244	BARRY JONES
50.6	12	8	2	0	0	0	+	3245	JEANETTE JONES
39.3	9	6	1	0	0	0	+	3246	CURTIS KING
17.1	6	4	0	0	0	0		3247	BETTYE LEWIS
57.0	11	6	1	0	0	0		3248	RICKY LEWIS
31.6	7	5	1	0	0	0		3249	RHONDA PAGE
32.2	6	4	0	0	0	0	+	3251	CHARLES POLLARD
7.4	4	1	0	0	0	0	+	3252	KEITH RICHARDSON
60.9	13	9	5	3	0	0	+	3253	OMAR SORIANO
49.1	10	6	1	0	0	0	+	3254	LANA TERRY
60.6	12	7	3	1	0	0	+	3255	VICTORIA TORRES
49.3	12	6	2	0	0	0	+	3256	BOBBIE VICKERS
61.6	15	9	2	0	0	0		3257	PEYTON WATKINS
38.3	9	5	1	0	0	0	+	3258	YOLANDA WATTS
23.9	8	5	0	0	0	0		3259	TERRY WILKS
0.0	0	0	0	0	0	0		3982	MARIETTA WOMACK
62.9	14	7	2	0	0	0	+	4474	GARY ODLE
0.0	0	0	0	0	0	0		4475	LISA JOSEPH
AVERAGES:									
48.8	10	6	1	0	0	0			
MINIMUMS:									
7.4	4	1	0	0	0	0			
MAXIMUMS:									
77.0	17	11	5	4	0	0			

Figure 3. On-line Utility Program
For Class Information
Reading Program

name. At the end of the report, as summary statistics, are printed within-class averages, minimums and maximums for accumulated minutes and the strand section numbers.

A report on an individual student is also available to the teacher. See Figure 4 for an illustration of the student's report. When a teacher requests information on a student, the program will provide the student's name, class, grade and student number, the section number, and the specific items he is working on in each of the six strand sections. It will also give the total number of minutes he has been on the reading program. At a glance the teacher can note a student's progress in a strand, and the particular items in the exercise. These data give an accurate, up-to-date evaluation of the student's progress as well as an indication to the teacher of the areas in need of reteaching.

Concluding Remarks

It may be evident at this point that the CAI program described above is in no way intended to replace the teacher. On the contrary, it is a teacher's tool and can free her for more creative, generative forms of instruction. Using the program is the teacher's option, and although her cooperation is sought, we anticipate a time when more and more teachers will turn to CAI to relieve them of the tedium of classroom drill-and-practice routines.

Some of our optimism in this regard is based on a recent survey among teachers from different schools whose students took daily CAI lessons in the reading program. All of the teachers had positive

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                INDIVIDUAL STUDENT
STUDENT NO:  3232
3232   VIZAR  BALCITA
 L-17   A    V    Y
 W-9   WATER  WARM   WAS
PH-4    -IG    -IT    -IN
SP-4   LOG   DOG   FROG
CC-0
CS-0
ACC. MIN.:  66.3
```

Figure 4. On-line Utility Program
For Individual Student
Reading Program

feelings about the program; close to ninety percent felt that CAI allowed students maximum individualization in learning. Although half of the teachers were uncertain about whether students learned facts faster in classroom groups or with CAI, they all agreed that teletype programs provided important drill routines for material the teachers initially presented in class. Again, ninety percent hoped the program would continue in their schools.

Seventy percent of the teachers were emphatic in expressing their views that the children interacted well with the program: the children did not feel isolated or neglected by teachers; the alert student was quick to catch a missed cue by the machine and the slower student gradually learned to comply to the program's request for a response. This brings us back to the students' viewpoint. We note that in CAI as opposed to classroom procedures, a wrong answer is never a defeating public pronouncement. In CAI, the computer never makes judgments, never frowns, scolds or becomes impatient, and always greets a student with a cheerful, "Welcome to reading!"

As the program now works, a child is on the system for about twelve minutes per day. This time is neither arbitrary nor fixed, but was found to be the necessary time to maintain the students, on a class average, at grade level. Given longer periods, children could advance more rapidly. Another possibility would be to have slow learners spend more than twelve minutes per day on the program, either extending the single session or having more than one session per day so that those students who were lagging behind the norm could be brought up to the class average.

The twelve-minute period was thus selected as a minimum time for maintaining our particular students at grade level in reading. It is important to note that this time period did not tax the young children's span of attention. In fact, in one experiment individual students have run on the system for as much as 36 minutes per day and the rate of progress per hour was equivalent to that of three individual twelve-minute sessions. In this situation, the old notions of limits on attention span do not seem appropriate; students engaged in a rich and interactive form of reading instruction show little evidence of habituating or losing interest in the task.

Allow us to point out again that this program is experimental. It is a research tool from which we learn and are able to act upon day by day. Feedback from the teachers and the students, as well as the response data we are collecting and analyzing, will permit us to work out better optimizing procedures for exercises, branching among strands, distribution of review exercises, and programming subroutines that improve the presentation.

President Nixon remarked in his special message on education reform not too long ago that, "Achievement of the right to read will require a national effort to develop new curricula and to better apply the many methods and programs that already exist. Where we do not know how to solve a reading problem, the National Institute of Education would undertake the research. But often we find that someone does know how, and the Institute would make that knowledge available in forms that can be adopted by local schools."

We propose that the CAI program described above warrants a large-scale tryout in a metropolitan city where all children in grades one through three, regardless of background, have the same opportunity for daily CAI sessions. The cost of the program, given total commitment, would be less than the 40¢ per child per day quoted above. No costly building program would be necessary. In fact, no new buildings at all. The equipment necessary for the program could be housed in the present physical plants. Nor would extensive teacher training be required. With regard to individualization, not only does CAI achieve greater individualization in the portion of the curriculum it teaches, but it allows the teacher freedom to achieve greater individualization in her classroom teaching. The total increment of individualization, therefore, is greater than the sum of what CAI and the teacher can achive alone.

Admittedly then, the low level of reading is a national problem. Everyone concurs that raising that level of reading is an admirable goal. We fail to see that a great abyss separates the problem from the goal. The technology and basic science necessary to solve the problem are already in hand. There is no question that CAI in initial reading is a feasible and cost effective way to reach the goal.

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