Designing Effective Computer-Based Education to Teach Reading to Nonliterate Adults

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Abstract. The basic skills learning system is a modularized network of computer-assisted tutorials, drills, tests, printed materials, and videotaped presentations directed at improving the basic reading, math, and language skills of adults who have mastered these skills at a level above third grade but below the eighth. Performance data from demonstration projects in Maryland, Texas, and Minnesota indicate that adult and adolescent learners made significant grade-level gains in reading and math and that dropout rates were reduced from 60% to less than 5% in some adult basic learning centers. These dramatic gains seem directly attributable to computer technology which utilizes effective instructional strategies. The purpose of this paper is to present the instructional rationale used in the design of this learning system and to define some of the teaching strategies which seem to directly impact reading achievement gains.

Teaching Strategies and Computer Courseware

Programs of adult basic education have the educational goal of expanding employment opportunities for participants. Learning experiences are planned so that learners will (Wilson, 1978):

1. Develop a degree of self-confidence that will enable them to respond positively to employment opportunities and to adapt to the demands of jobs or training.

2. Develop a command of necessary life skills, with particular emphasis on literacy and numeration.

3. Discover the type of work they like; identify and begin to develop those skills associated with this work.

4. Improve their ability to learn and adapt to changing situations.

The Basic Skills Learning System (BSLS) described by Caldwell and Rizza (Note 1), like many other programs, has these goals within its planned curriculum but is unique because it seeks to develop these goals through a modular network of computer-assisted lessons, drills, tests, printed materials, and videotaped presentations. As a total package, these strategies are directed at helping adults whose skills are above the third-grade level but below the eighth-grade level improve their competency in reading, math, and language arts. Because of its modular nature, the instructional system is capable of responding to wide differences in age levels, achievement, and interest by using individualized instructional techniques that locate and apply those instructional methods that will enhance learning motivation, reinforce student achievement, and develop an improved model of management for student learning.

Evaluation studies conducted at three sites between January and June of 1978 have yielded encouraging results about how well the BSLS achieves the goals of adult basic education cited at the beginning of this article. Rizza and Walker-Hunter (1978) report dramatic gains in reading and math achievement as well as improved learner motivation, attitude, and self-concept development.

These results are encouraging because they demonstrate that effective curriculum models using well-designed instructional paradigms can offer high-quality instruction in the basic skills through computer-based delivery systems. Other studies also have demonstrated the effectiveness of computers for teaching the basic skills, but unfortunately few of them have discussed the nature of

the instructional models used in the curriculums. Instead, these reports imply that the results obtained are largely due to the uniqueness of the computer system through which instruction is delivered rather than the effective use of the teaching strategies within the computer courseware. The purpose of this paper, therefore, is to explain the instructional rationale that is used in the design of the BSLS and to define some of the teaching strategies that seem to be responsible for the dramatic gains achieved at test sites across the country.

Field tests of the BSLS at sites in Minnesota and Maryland, for example, have demonstrated significant gains in reading achievement among adult learners. These learners upon entering the system are diagnosed using criterion-referenced inventory tests that establish an achievement profile for each student. Progress is then monitored through lessons arranged hierarchically in five strands. Each strand (structural analysis, vocabulary development, literal comprehension, interpretive comprehension, and evaluative comprehension) contains lessons ordered in difficulty levels ranging from the third through the eighth grade. Instruction is based upon the progressive mastery of reading subskills that emphasize the successful accomplishment of the instructional objectives particular to each lesson before the learner proceeds to more difficult content. Tables 1 and 2 summarize the results of using such a system with a variety of adult learners (Caldwell & Rizza, Note 2). Table 1 presents data collected between February and June 1978 from the Adult Learning Center in Baltimore, Maryland.

Two projects in Minnesota (see Table 2) compared the computer-based BSLS with traditional educational programs used at each site. Each site used approximately 20 students. Data were collected between February and June of 1978.

In summary, adult learners using the BSLS to improve reading skills averaged a 1.12 grade-level gain in reading achievement after an average instructional time of 13.0 hours. Further analysis of the data reveals that an average learning time required to generate a 1.0 grade-level gain would require 18.34 hours of computer-based reading instruction. A more detailed analysis of these data is offered by Rizza and Walker-Hunter (1978).

These preliminary results are encouraging. The motivational acceptance of the learning system is a result of extensive use of an interactive computer-based configuration integrated with a multimedia support package. This multisensory approach is often successful with students who have difficulty achieving in text-oriented, passive-learning environments and carries with it a compelling novelty effect that most learners find extremely motivating. This effect has been sustained quite often across long periods of instruction.

The presentation of reading instruction through the computer-based learning system offers illiterate adults a number of advantages that compensate for many earlier learning problems. The curriculum is individualized so that it adjusts learner progress in reading subskills by teaching to points of weakness and it provides for more opportunities for interaction and feedback than would be expected in a traditional classroom. Teaching for mastery ensures large measures of success and builds student confidence and feelings of self-worth as they progress through individual clusters. A multisensory learning environment provides a rich experience in which to learn new concepts and ideas. Finally, the modular organization allows for flexible adaptation to a wide variety of learning needs and situations (Caldwell & Rizza, Note 3).

The instructional rationale for establishing and developing teaching strategies for the reading component of the BSLS is derived from a recognition of certain conditions that seem to enhance verbal learning (Dececco, 1968). These conditions include meaningfulness, reinforcement, instructions to learn, and practice.

TABLE 2. Results from Minnesota study

Site	BSLS	Traditional
Stillwater Prison Stillwater, Minnesota	1.62[a] grade level gain/ 15 hours of instruction	0.0 grade level gain/ 15 hours of instruction
Fair Break (Adult Education Center) Saint Paul, Minnesota	1.80[a] grade level gain/ 11 hours of instruction	0.0 grade level gain/ 11 hours of instruction

[a]Statistically significant gain

Meaningfulness

Noble (1952) defines *meaningfulness* as the number of different associations elicited by a verbal unit. A learner's ability to make associations will strongly influence his or her rapidity of learning. The more frequently a word or phrase appears in a child's environment the more familiar it becomes and consequently the greater the probability that meaning for the new word will be associated with other familiar words.

The sophisticated capabilities of the modern computer system allow language instruction to take into account each student's response. Materials are designed to adapt the amount and extent of instruction to the individual needs of each student. Common techniques such as self-pacing and individualized branching usually employed in programs of individualized instruction are augmented by the ability of the learning system to handle student controlled selection of instructional techniques while providing for a tailoring of teaching to individual performance. In this way, learners are helped to select the most appropriate pathway through the material and are given both regular and distributed practice in language skills. Instruction presented through such a

TABLE 1. Results from Baltimore study

Number of students	Average time on PLATO per student	Average grade level gain	Expected school time for similar growth
24	15 hours	0.8 grades	120 hours

learning system provides the learner with a rich and varied language experience and provides immediate and frequent feedback to responses.

In the BSLS this important condition of verbal learning has been incorporated in several different ways:

1. Great care has been taken to match reading content to student achievement levels. Syntactic structures and vocabulary levels in reading selections are appropriately designed for the learner's grade placement. For example, reading content presented on the display panel never exceeds 25 words at the fourth-, 50 words at the sixth- or 75 words at the eighth-grade level. Similarly vocabulary increases in difficulty and syntax becomes more complex. As students progress through the curriculum, therefore, they are continually challenged with more complex material that has been carefully correlated with concepts that were mastered earlier in the curriculum sequence.

2. Subskills are sequenced in a hierarchical arrangement so that they are reinforced across strands in the following manner: (a) Comprehension is made a part of each lesson, and (b) Vocabulary development is introduced at every opportunity, although no more than five new words are introduced in a single lesson.

3. Reading material is presented in very small segments to ensure concept mastery.

4. Students are allowed control over the learning sequence whenever possible. They are free to choose from many options within lessons. These include opportunities for reviews, remedial sequences, diagnosis, and choice of reading content.

5. Feedback is made more meaningful by making it personalized and specific to student response sequences (e.g., "You did well, Allen, but would you like to review prefixes before going to the next lesson?")

6. Graphic and animation capabilities are used extensively to help create cognitive structures necessary for comprehension of key ideas and concepts.

Reinforcement

This is possibly the most important condition of verbal learning. Reinforcement is a confirmation of the learner's correct use of language within various contexts. Language assumes meaning within the context in which it is used. This context has been called the "semantic environment" (Postman, 1976). If communication is to occur, it requires not just a recognition of language but an ordered situation in which language assumes meaning. The semantic environment defines the meaning of words and, therefore, the nature of the communication. Reinforcement is critical in helping learners confirm whether or not their attempts at using language communication within the semantic environment are effective and it helps the learner derive meaning from other new contexts.

In the BSLS reinforcement patterns have been constructed to shape reading behaviors in a manner that will reduce student frustration levels and increase the probability of student success. A typical reinforcement pattern is shown in Figure 1. This type of reinforcement pattern contributes to meaningfulness because it:

1. Provides specific information that helps to correct student behavior and achieve the desired outcome.

2. Reduces the frustration often experienced by learners in computer-assisted instruction (CAI) programs that simply provide a "no" response to an incorrect answer. This type of reinforcement is unsatisfactory because it provides no specific feedback to enable the learner to discover correct responses. Instead, learners are forced to guess until the correct answer is found.

Instructions to Learn

Associations that contribute to the meaningfulness of verbal stimuli can be achieved more quickly if the learner develops a state of readiness induced by directions or verbal organizers within the environment. This verbal "set" helps focus the learner's attention on specific stimuli within an environment bombarded with verbal stimuli. The BSLS provides instructions that aid student learning in various ways:

1. In many CAI lessons students often make mistakes on practice exercises because they do not understand directions. Exercises that require typed responses seem particularly prone to this problem (Caldwell, Note 4). This system has taken great care to provide sample exercises before each practice to reduce this type of mistake. In this way, responses can be judged on the basis of concept mastery rather than on a lack of understanding of the response mechanism.

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Exercise: Change the following word by adding "ing."
(Student must type the correct response.)

Come_____

(A correct response on the first try warrants positive reinforcement such as "great," "super," "well done," or "excellent." These and other reinforcing statements are generated randomly from a list of 20 or 30 possible statements. Incorrect responses follow a pattern of shaping and cuing that leads the student to the correct answer.)

After the first incorrect response, the student sees:

Come_____ **(drop the "e")**

(The student is cued by being reminded of the rule under examination.)

After the second incorrect response, the student sees:

Come_____ **(come + ing)**

(In this second prompt, the computer system animates the "e" in "come" and drops it from the equation.)

After the third incorrect response, the student sees:

Come **Coming**_____

(If on the third try the student still has not typed the correct response, the correct answer is given and the student moves on to the next problem.)

FIGURE 1. Typical BSLS reinforcement pattern.

Continued from page 18.

2. Each lesson states the performance objectives to be mastered in that lesson in terms each student can comprehend. Students, then, have a clear idea about the learning behaviors expected of them.

3. Throughout each lesson students are presented with checkpoints and summaries of what they have learned and what they will be learning in future segments of the lesson. This helps develop for the learner a structure that we believe helps organize the concepts presented for study.

4. All directions are written in simple language and illustrated with examples as stated above.

Practice

Research on skill learning has documented well the effects of practice: The longer the learner works at learning the more he or she will learn (Underwood, 1964). Research on verbal learning, however, has not resulted in the same degree of certainty about this effect. Essentially, the value of practice, particularly in verbal learning, depends less upon the amount than on the nature of the practice. More research is needed to discover which types of practice (e.g., massed vs. distributed) are appropriate to various types of learners, what are the effects of overlearning, and whether the whole or part method of presentation is most effective at various levels and with various materials. One form of practice in the BSLS that significantly enhances the development of reading skills was the typed response. When students were allowed to type their responses rather than simply choose from alternatives, it seemed to produce these advantages:

1. Students seemed to express more favorable attitudes toward writing.

2. Spelling skills and the ability to generate language improved.

3. Personalized feedback was made possible.

The typed response did have its negative features as well. For example, typing very often became time consuming because students made many errors typing. This had the effect of distracting students from the concept under consideration and focusing their attention on the typing task. A related problem was that many errors in typing were judged by the computer to be incorrect responses and routed students into remedial sequences when they in fact knew the concept being studied. Also, if typed responses are not carefully cued, learners are often forced into an "open loop," i.e. they have little idea about what is expected of them and become frustrated trying to type a correct response that will ultimately advance them to the next frame. This is a common error made by instructional designers and has an extremely negative effect on learners.

The instructional considerations mentioned above are important ingredients in the recipe for success in teaching basic skills. In the BSLS these conventions have been incorporated into a series of tutorial and drill-practice strategies that are set into strand and cluster configurations.

Strand

A set of concepts and skills which have been ordered hierarchically according to common and expected outcomes is called a *strand.* In reading, these strands are structural analysis, vocabulary development, literal comprehension, interpretive comprehension, and evaluative comprehension.

Cluster

Within strands content is further divided into subskills. Related subskills expressed in behavioral terms are grouped in a meaningful way in clusters. Each cluster contains tutorial, drill and practice, review help sequence, off-line activity, and mastery test.

Tutorial. Tutorial is a presentation of new material to the learner on the objectives within a cluster. It is characterized by concept explanation, demonstration, explanation, and/or inquiry, as well as student assessment, branching, and feedback.

Drill and practice. A series of drill examples of similar form on each objective in the cluster is presented in drill and practice. It is designed to strengthen the newly acquired skill(s).

Review help sequence. This is a capsule form of the cluster tutorial for review and refresher purposes.

Off-line activity. An off-line form of the drill and practice materials is presented as off-line activity. It allows students to strengthen the newly acquired skills when they are away from the terminal.

Mastery test. Mastery test presents a series of test items designed to evaluate the student's achievement across competencies addressed by the cluster.

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The Future of CAI

Summarizing, then, the BSLS assesses each learner for placement and diagnostic purposes by a series of inventory assessment instruments that accompany each strand in the system. Progress, retention, and achievement are measured by the mastery and retention tests that accompany each cluster throughout the instructional system.

In short, computer-based systems can be designed on a large scale to provide basic skills instruction over a wide range of abilities and grade levels. Further development and use of these systems offer great potential for individualizing instruction in ways not possible before interactive computer systems became available for wide use. Careful attention to the organization of curriculum materials within these systems and using effective teaching strategies can improve the effectiveness of these systems further and maximize the benefits for potential users—at present and in the immediate future.

Reference Notes

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