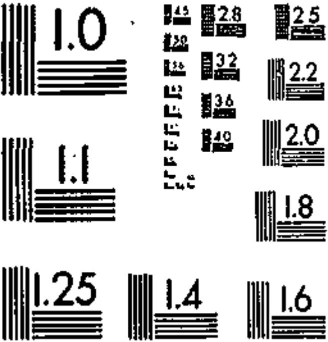

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ABSTRACT

The report describes the initial design and planning phase of a 3-phase project to adapt, develop, and evaluate computer-aided instructional materials in elementary education basics (specifically word recognition, reading comprehension, and mathematics) for Alaska Native and American Indian students. Section 1 provides background information about the history of Indian education and computer use in schools. Section 2 outlines the project's objectives, calendar, and products. Section 3 describes the three curriculums and computerized diagnostic aids. The beginning reading curriculum focuses on visual discrimination, letter identification, sight words, word patterns, sentence comprehension, and paragraph comprehension. The reading comprehension curriculum consists of a management system, user identification system, and series of exercises to provide drill, practice, and help across five skill areas. The arithmetic curriculum is divided into levels according to grades at which skills are usually practiced for mastery. The diagnostic aids include tests for shape judging, digit memory, location memory, word memory, word/shape judging, shape recognition, word coding, vocabulary, and shape memory. Section 4 reports results of pilot studies conducted at the Waterford School (Utah). Section 5 presents recommendations for material adaptation and curriculum development. Final comments and a list of references conclude the report. (NEC)

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Final Report - Phase I

(1 October 1982 - 30 June 1983)

Computer-Aided Instruction

In

Education Basics for Indian Students

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Indian Affiliates Incorporated

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Final Report — Phase I

Computer-Aided Instruction in Education Basics for Indian Students

Indian Affiliates Incorporated

PROJECT ABSTRACT

Indian Affiliates Incorporated is to adapt, develop, and evaluate computer-aided instructional materials in elementary education basics, specifically word recognition, reading comprehension, and mathematics for Native American, Native Alaskan, and American Indian students. The benefits of computer-aided instruction have been widely noted and well documented in the research literature. Most important for populations of American Indian students are the benefits of easy replication (materials that work in one setting can easily be transported and made to work in another setting), the perceived culture fairness of materials presented and judged by a computer, the extensive individualization capabilities of computers to tailor materials specifically and in detail for individual students, the ability of computer-aided materials to successfully and substantially improve student achievement independent of the abilities and interests of the classroom teachers whose students are using them, and the capability of computer-aided materials to produce relatively standardized enhanced levels of student achievement for geographically dispersed populations of students.

This project is to be completed in three phases. Phase I began 1 October 1982 and has lasted for 9 months. This phase was for project design and planning. Phase II is designed for development and preliminary evaluation of the materials specified in Phase I. During this phase the emphasis will be on developing

these materials and validating them with a wide range of Indian students, grades one through nine. Phase II is anticipated to begin 1 July 1983 and is scheduled to take 12 months to complete. Phase III will demonstrate and evaluate the transportability of materials developed under this project to the wide variety of settings characteristic of Indian education in the United States. Phase III is scheduled to begin 1 July 1984 and is expected to take 12 months to complete.

This project is intended to provide a major impetus for the adaptation and use of computer-aided materials by Indian children. Materials of this sort have achieved dramatic success in improving student achievement among other populations. A basic assumption of this project is that it is past time for Indian students to participate in the benefits to be achieved by using these materials.

Final Report - Phase I

Computer-Aided Instruction in Education Basics for Indian Students

Indian Affiliates Incorporated

BACKGROUND

Indian Education

Formal Indian Education supplementing age-old, informal tribal practices predates the American revolution. In 1568 the Jesuits established a school for Florida Indians in Havana, and 50 years later the Council of Jamestown, Virginia, voted to provide government-sponsored education for Indian children. In the 1700's colleges such as Dartmouth and Hamilton grew out of Indian schools. The federal government has been active in Indian education since 1794 when the first treaty providing for Indian education was signed. Since that date, the federal government has had the primary responsibility for educating American Indians in the United States. Today the federal government spends over $500 million per year for the education of Indians. About half of these funds go for educating students in Bureau of Indian Affairs schools where the average daily attendance is about 44,000. The remaining half of these funds goes to meet the special and unique needs of Indian students in public and contract schools. There are nearly 300,000 Indian students in these schools.

Despite the longevity and magnitude of these efforts, there is little reason to conclude that they have been successful. Absentee rates are high. Dropout rates in high school are about twice as high for Indian students as they are for the general population. Those who do graduate from high school score about three years behind their classmates in academic achievement, and only about 7% of Indian high school graduates complete college (Bass and Tonjes, 1970). There seems little reason to attribute these problems to mental ability. Levensky (1970) found that 1,700 Indian children who took a non-verbal test of intelligence achieved an average IQ of 101.5 which is slightly superior to the average of Anglo children. On an earlier study completed in 1942, Havighurst and Hilkevitch (1944) administered a battery of non-verbal intelligence tests to a representative sample of Indian pupils from six tribes. These pupils scored an average IQ of 100.2, again slightly above the national average of Anglos.

There is, of course, a great deal of evidence that the school achievement of children depends largely on their experience in their family and local community. If parents do not read or read very little, do not speak English, do not use complex sentences or express themselves in sophisticated ways, their children are likely to be slow in learning to read English language materials and will in turn experience the often noted problems of poor readers in all school subjects. Adams, Higley, and Campbell (1977) show that the first semester college grade placement average for Indian students raised on a reservation is almost exactly half that of students who have spent seven to nine years on placement in a town with a volunteer foster family. Additionally, McDonald (1978) reported some recent efforts by the National Institute of Health to identify minority scientists in the biochemical fields. These efforts turned up less then ten Ph.D. scientists who were also enrolled tribal members. McDonald also reports that the last count of members of the American Indian Association of Physicians totaled only 22 medical doctors.

More than anything else, these dismal statistics may be due to communication problems. For Instance, Rosier and Holm (1980) reported that a sample of approximately

5,000 Navajo students was about .7 of a grade level equivalent behind national norms in second grade on the Paragraph Meaning subtest of the Stanford Achievement Test and that this difference increased to a grade level equivalent of about 2.4 behind national norms by the sixth grade. In any event, it seems hard to deny that in school achievement, Indian children, on the average, are disadvantaged. Their parents are typically poor, often illiterate, and inexperienced in the ways of modern technical culture. It should be emphasized that many Indian children are advantaged in other ways; their tribal cultures are rich and in harmony with the natural universe, they enjoy a satisfying ceremonial life, and their family ties often give Indian children a firm sense of security. However, these very advantages may contribute to the socioeconomic conditions that lead Indian children to do poorly in school from the start.

In light of these observations it is interesting to note that public education in general has not fared well during the last 15 years. Despite an increase in real 1978 dollars from $114 billion expended on public education in the 1969-1970 school year to $141 billion expended in the 1978-1979 school year, an increase of 24%, and despite an increase in the percentage of Gross National Product devoted to education from 3.4% in 1950 to 7.2% in 1978 (Dearman and Plisko, 1980), there has been a decrease in measured national skills. In the last ten years, college entry Scholastic Aptitude Test scores have declined about 7% in mathematical achievement and 11% in verbal achievement ("College Bound Seniors," 1979). This decline is uniform across the country; it is unrelated to economic, race, or geographic background. The lack of return may indicate, as Heuston (1980) has argued, that traditional instruction has matured to a point of diminishing returns. One promising way to increase the productivity of current education and training institutions may be to develop new technological tools and incorporate them in these institutions. That the productivity of these institutions must be increased seems self-evident. In an era of increasing technological complexity, the proportion of individuals with high proficiency in basic skills needs to rise, not fall nor even remain level. There is substantial need for government, industry, and educational planners to seek new techological solutions for the demands and concomitant problems posed by current and projected education requirements.

Computers in Schools

The microcomputer, in conjunction with the videodisc in certain applications, appears to offer just such a solution. This device can change the educational delivery system dramatically by harnessing the rapidly increasing power of microelectronics to aid teachers in individualizing and improving instruction. Much as the limits of the communication delivery system using the Pony Express were transcended by changing the delivery system through harnessing the power of electricity in the telegraph, so the microcomputer can harness the power of electricity to do exponentially more work for the student and the teacher. The microcomputer accomplishes this by making students active and productive learners who receive individualized instruction with consistency, patience, and privacy.

The crushing workload of the teacher who is trying to manage the individual progress of 30 or more students can be dramatically improved through the support of this new delivery system. It is notable that the current revolution in microcomputers has shown no signs of abating. The cost effectiveness (i.e. cost in relation to the capacity and speed) of computers has doubled every two years for the last decade, resulting in a 32-fold increase over a ten year period. This trend is expected to continue throughout the 1980's. The decreasing cost of microprocessor chips, and of large scale integrated circuitry, is also notable. The cost effectiveness of chips doubles every 14 months. The cost of a newly announced chip is generally about $50 and it usually drops to $5 in two to three years before the chip becomes obsolete and is replaced by a more advanced chip. The cost of personal computers presently in the $500 to $600 range will not drop in relation to the declining cost of microprocessor chips, due largely to the cost of marketing and housing equipment. However, the power and capacity of personal computers will increase at the rates noted earlier without a concomitant increase in cost (Jones, Holton, and Stratton, 1982).

Schools are beginning to notice this revolution. In 1970 only about 15% of school districts used computers for instructional use. By 1980 about 70% of schools districts were using computers for instructional use, and by 1985 it is estimated that about 90% of all school districts will be using computers for instructional use (Blaschake, 1981).

Moreover, it is notable that in some curriculum areas, computers used for instruction have proven to be extremely effective. Orlansky and String (1980) reported that their survey of 40 training and education applications of computers found that in almost every case the use of computers resulted in equal or greater educational achievement combined with a median student time savings of 33% and a time savings for some courses as high as 80%. In evaluation studies where time to teach has been held constant and the variable of interest was educational achievement, some studies have shown that the use of computers produced improvements of three and in one case five times the educational achievement that could be expected from the use of traditional classroom technologies (e.g. Fletcher and Suppes, 1975). In a review of 51 studies of computer-aided instruction in secondary schools, Kulik, Bangert, and Williams (1983) found that the computer-aided instruction raised students' scores by about .32 standard deviations on final examinations. In any case, there are some dramatic changes occuring in the technologies used to educate children, and it is past time for Indian education to join in these technological improvements.

A review of the literature revealed only one study that had been completed in evaluating the use of computers with Indian students. This was a study completed by Suppes, Fletcher, and Zanotti reported in 1975. This study was limited to improvements in arithmetic computation, but the results in this domain were quite favorable. The authors extrapolated from their 60 day evaluation that one could expect the average Indian student to gain about 1.5 in grade placement in arithmetic computation over a full 180-day school year based on daily computer sessions of only 10 minutes. No studies have been found reporting the use of technology in language related subject areas for American Indian students. These curriculum areas are most imporant, and given the successful results achieved with other populations of both advantaged and disadvantaged students some effort should be made to see if equivalent successes can be achieved within American Indian populations.

OBJECTIVES

The single objective of the work reported here is to improve Indian education in elementary school reading and arithmetic through the development, adaptation, implementation, and evaluation of a significant and proven capability, namely computer-aided instruction. This capability has the following characteristics:

* It works. There is now a history of 15 years of evaluation studies showing that used properly computer-aided instruction can significantly and substantially improve instructional achievement.
* It is easily replicated. The computer-aided materials achieve their benefits relatively independent of the abilities and enthusiasm of classroom teachers whose students use them.
* It is perceived to be culture-fair. In computer-aided instruction, materials are chosen, presented, and judged by computer without the socio-psychological implications of classroom interactions.
* It individualizes instruction. The portions of curriculum materials that are amenable to computer presentation can be tailored explicitly and in detail to the needs of individual students.
* It standardizes instruction. The portions of curriculum materials that are amenable to computer presentation can help produce relatively standardized levels of student achievement for widely geographically dispersed students.
* It is relatively private. Students progress at a rate that is determined and, if desirable, known only by them. Older students who must begin with relatively easy materials escape the embarrassment of classroom visibility and, equally significant for American Indian education, students who are progressing relatively rapidly can do so without any public notice and, in fact, without knowing it themselves if this appears desirable.

The cost of the computer hardware for this project is about $2,500 per student station. This is less than the cost of a well equipped personal computer. However, the student stations used here are far more powerful than a personal computer. They use a processor that runs about four times faster; they access about four times more direct access memory; they access more than twenty times the on-line disc storage of a personal computer; they have the full graphics capability of a personal computer; and they provide a large vocabulary of randomly accessible audio (the student stations can "speak" to the students in any language) which is only available as a rarely provided and very expensive add-on to personal computers. Amortizing the cost of these student stations over five years and assuming that each student station can service about 15 students a day, yields a per student per year cost of less than $35. This cost is based on the current state-of-the-art in computing today. It is reasonable to expect substantial decreases in this cost over the next three to five years.

Work under this project is scheduled to progress in three phases. Phase I began 1 October 1982 and lasted for 9 months. This phase was for project design and planning. The products from Phase I are:

* Survey of English as a second language for American Indian students.
* Survey of mathematics concepts for American Indian students.
* Specifications for computer-aided reading materials for American Indian students.
* Specifications for computer-aided mathematics materials for American Indian students.
* Report on a conference in which the work of the project was reviewed by a panel of experts in Indian education.

The surveys for English (Fletcher, 1983a) and mathematics (Fletcher, 1983b) were completed in March, 1983. The specifications for reading and mathematics are presented in the Curriculum Recommendations section of this Final Report. The activities and recommendations of the conference were summarized by Fletcher and Sawyer (1983).

Phase II concerns development and preliminary evaluation of the materials specified in Phase I. During this phase the emphasis will be on developing these materials and on using them with a wide range of Indian students, grades one through nine, in operational school settings.

The principal products from Phase II will be:

* new computer-aided reading materials adapted and designed for American Indian students;
* new computer-aided arithmetic materials adapted and designed for American Indian students;
* preliminary evaluation of those materials with American Indian students in grades one through nine.

Phase II is scheduled to begin 1 July 1983 and is expected to take 12 months to complete.

Phase III will demonstrate and evaluate the transportability of materials developed under this project to the wide variety of settings characteristic of Indian education in the United States.

The principal products from Phase III will be:

* full scale evaluation of all relevant computer-aided materials in the following settings:
    - an on-reservation school under Indian control
    - a near-reservation school with a substantial Indian student population
    - a boarding school for Indian students
* systematic guidelines and procedures for implementation of computer-aided instructional materials in the three settings listed above.

Phase III is scheduled to begin 1 July 1984 and is expected to take 12 months to complete.

DESCRIPTION OF MATERIALS

Project design and planning in Phase I centered on three curriculums and a set of computerized diagnostic aids. The curriculums concern computer-aided instruction in (1) beginning reading, emphasizing word recognition skills, (2) intermediate reading, emphasizing comprehension, and (3) elementary school arithmetic. The computerized diagnostic aids, or Learner Profile, were developed to provide each student with the equivalent of 2-3 days of individualized, one-on-one school counseling. Using a computer makes such a process practicable both in terms of time--a few hours instead of a few days--and money--it can be accomplished by a single computer rather than by an army of school counselors. Descriptions of all four of these materials follow.

Beginning Reading Curriculum

WICAT has developed two curriculums that are appropriate for reading in elementary school. One of these emphasizes word recognition and is intended for use in kindergarten through third grade. This curriculum uses randomly accessed, digitized audio output so that students do not have to read instructions given by the computer in order to learn how to read. The second curriculum emphasizes reading comprehension and is appropriate for use in grades three through nine. Development of both of these curriculums was based on an idea early expressed by Carroll (1964), that reading can be analyzed into two processes: the construction or reconstruction of a spoken message and the comprehension of messages so constructed. Carroll went on to recommend that "these two processes--speech reconstruction and the apprehension of meaning--should (not) be separated in procedures of teaching. There is evidence, in fact, that the teaching of the mechanics of speech reconstruction (techniques of word recognition) is best done with materials which are maximally meaningful to the learner (p. 338)." This latter recommendation has been followed as closely as possible in the development of both curriculums by relying on the substantial capability of the WICAT computers for presenting graphic information. Additionally, both of these curriculums were designed to supplement whatever reading instruction occurs in the classroom. It was assumed to be far easier to adjust and modify the computer programs used for instruction than to adjust and modify the established practice of classroom teachers.

The reading curriculums use a "strands" approach to computer-aided instruction. This approach was developed and described in general by Suppes (e.g., 1967) and in the specific case of reading by Fletcher (1979). The term strand is used to identify a basic component skill of reading. Students move through each strand in a roughly linear fashion. Branching or progress within strands is criterion dependent; students proceed to a new exercise or new materials within a strand after they attain some (individually specifiable) performance criterion in the current exercise or material. Branching between strands is both criterion and time dependent. During a given session students move from one strand to take up where they left off in another after a given (again, individually specifiable) amount of time, regardless of what criterion levels they reach in a strand. However, over a period of sessions students will distribute their effort among the strands based on their level of mastery of the reading materials, inasmuch as entry to each strand depends on progress in earlier strands.

The beginning reading curriculum consists of the following strands:

Visual discrimination. In this strand students match upper and lower case target letters with one from a list of four upper and/or lower case letters drawn from lists in three categories: low visual confusability, medium visual confusability, and high visual confusability. Low confusability pairs are used primarily to orient children to the discrimination task. The curriculum is designed so that students who perform well in any of these tasks proceed rapidly through the strand.

Letter identification. The letter identification strand requires that students be able to identify each letter in the alphabet by finding it on the computer display screen after the name of the letter is "spoken" by the computer digitized audio system.

Sight words. The sight word strand serves four major purposes: to teach students to recognize a substantial number of words that occur with high frequency; to reduce the students' reliance on mediated word recognition techniques; to provide students with candidate words that they recognize immediately and can use as models for word analysis technique development; and to enable students to recognize words not conforming to word analysis. The sight words included in this strand are drawn from seven fairly standard and carefully developed word lists.

Word patterns. This strand is designed to provide direct and explicit practice with English word patterns. Exercises in this strand concentrate on initial and final consonants and medial vowels. Students are never required to rehearse or identify consonant vowel sounds in isolation. The smallest unit of presentation is a dyad, that is, a single vowel-consonant or consonant-vowel combination. The intent of this strand is to substantially improve students' abilities to "sound-out" the substantial number of words in English whose pronunciation is fairly closely and regularly related to their spelling.

Sentence comprehension. This strand allows students to "construct" sentences from groups of words presented on the computer screen. Although this strand was not developed specifically for Indian students, it is directly applicable to a situation described by DuBois (1979) who found that Navajo children reading English did not appear to understand that what they were reading was supposed to make sense. This strand emphasizes that groups of words organized into sentences are expected to make sense. The strand uses the graphics capability of the computer to show pictorially what the sentence "constructed" by the student means. If a student constructs a sentence that says "Bill kicks the ball," he will be shown a picture of a boy (presumably Bill) kicking a ball. Some free play is allowed by this strand. For instance, if a student constructs a sentence that says the ball kicks Bill, the computer will display a picture of a football with tiny legs kicking a boy (again, presumably Bill). Although the curriculum emphasizes word rocognition, the intent of this strand is to help students transcend single word comprehension and begin work with sentence comprehension as soon as possible. Additionally, of course, the intent of this strand is not just to convince students that words strung into sentences make sense but also to show in as concrete, visualizable, and graphic manner as possible what they mean.

Paragraph comprehension. The major purpose of this strand is to provide a direct seque for students who are finishing the beginning reading materials and are ready to begin work in the comprehension reading program intended for use by grades three and up. The emphasis in this strand is on paragraph comprehension. Usually one or two simple paragraphs are presented to students who are then required to answer five or six literal and interpretive comprehension questions concerning the paragraphs. The paragraphs are arranged so that vocabulary words that may be difficult for students can be highlighted by a moving cursor and can be pronounced and defined on student's request.

Reading Comprehension Curriculum

The reading comprehension curriculum consists of a management system, a user identification system, and a series of exercises designed to provide drill, practice, and help across at least five strands (skills) of reading comprehension. Philosophically, the program flows from the schema theory conception of reading comprehension (e.g. Kintsch and Greene, 1978; Rumelhart, 1975). This theory holds, roughly, that comprehension is an interactive process in which text, containing necessarily fragmentary information, activates a cognitive structure for organizing and augmenting that information. Hence, in the sentence:

"The notes were sour because the seam was ripped,"

a sentence many people find confusing as presented, the concept, "bagpipe" may provide an organizing structure for the relationship given between sour notes and a ripped seam. Without that concept, the words of the sentence may all be known to the reader, but the meaning of the sentence will be lost.

Additionally, the activation of the schema for "bagpipe" in the above example will produce additional meanings not stated in the sentence. The reader may think of kilts, plaids, the highlands, or any of a number of related concepts. Were the question: "Where might this sentence be uttered?" to be asked after presentation of the sentence above, it is the activation of the "bagpipe" schema which makes the answer "Scotland" come to mind more readily than "Russia," "New York," or "Calcutta." Simply stated, then, the purpose of the reading comprehension program is to assist students in linking textual data to pre-existing knowledge structures.

The program is organized as a mock newspaper. To use the program, the student goes through a routine called Sign-on. This routine requires that he enter his name and password, enabling the program to track and record his performance record. He then sees a display called Newsstand, which lists a menu of mock newspapers.

Each newspaper consists of five stories, or exercises. The newspapers are organized by grade level of readability and interaction type. The menu presented to the student is controlled by his current level of achievement. If the program recognizes the student as a fifth grade level reader, he will see a menu listing of fourth, fifth, and sixth grade level stories. Hence, the student always has an available pool of newspapers ranging from one year below to one year above his current level of achievement. His achievement level is continuously monitored, and is incremented one year if he scores 80% or better on an exercise above his current level of achievement. His achievement level is decremented one year if he scores below 50% on any exercise at or below his current level of achievement. The newspapers focus on fifth grade level curriculum, but range in readability from third to ninth grade.

After the student selects the newspaper from his menu, a front page display appears. The student can then select from among the five stories presented. The stories require that the students interact in one of the following ways:

Inference from text. The student is shown a frame of text with a multiple choice question. When the student answers, he is asked to justify his response by selecting those keywords from the text that led him to respond as he did. Both his answer to the multiple choice question and his choice of keywords are checked, and feedback is provided. If the student requests help during the interaction, a clue is provided. Both literal and inferential type questions can be asked in this protocol.

Deletion. The student is first presented with a scenario. He is an editor for the newspaper, and his writers are of marginal competence: They have written stories with sentences that do not belong. His job is to find those sentences and remove them from the story.

The student is then asked to read the story in its entirety. He is next asked to move a cursor through each frame, a sentence at a time. When he encounters an offending (e.g., irrelevant, redundant, or insignificant) sentence, he presses a key to delete the sentence. Feedback is provided for each sentence, explaining why it should be either removed or retained. The student can request help, and will receive a hint indicating how many and what category of sentences should be removed. This interaction emphasizes the abstraction of salient meaning and the ability to relate sequences of information.

Interpretation of graphically presented information. The student sees a story in which non-textually organized data is presented. Graphs, charts, tables, and maps are all used in the protocol. The student reads two to three frames of text, and then responds to a prediction question regarding the content of the graph, map, chart, or table to be viewed. He receives feedback on his response, and then sees the non-textually presented data.

Five to eight questions are asked, each of which the student answers by moving a cursor to the correct response on the display. He has two chances to get the correct answer, a miss on the first attempt results in the display of a clue to help him find the correct location. This protocol focuses on data interpretation, literal and inferential meanings, and location skills.

Argumentation. The student is given an editorial and is asked to perform five tasks. First, in multiple choice format during the first frame the student identifies the author's point of view. Second, by accepting or rejecting elements of a set of statements as points of proof, the student establishes, prior to reading the editorial, the necessary and sufficient conditions for accepting the author's point of view. Third, the student sees the text of the editorial and tests each frame to see if the author addresses the established conditions. Fourth, if the conditions are addressed, the student determines whether statements of fact or opinion were used to address the condition. Finally, the student decides at the end of the editorial whether or not the argument was valid. Helps, of course, are available for determing whether or not an item is addressed, and whether fact or opinion is presented. This protocol emphasizes critical reading skills such as analysis and evaluation based on criteria.

Vocabulary. The student sees a crossword puzzle organized around root words in this interaction. Two clues are available for each word, and the student can "buy" letters as well. When the puzzle is finished, the students sees an open-ended question that asks for the meaning of the root word in the puzzle. A synonym list and a spelling tolerance routine are used in answer checking.

Arithmetic Curriculum

The WICAT arithmetic program enables students to practice basic arithmetic skills and immediately find out how well they are doing. The program also offers tutorial instruction that students can request as they need it. The program is divided into levels according to the grades at which skills are usually practiced for mastery: Level A corresponds to grades one and two, Level B to grades three and four, Level C to grades five and six. The program can be used by older students or by whomever requires practice with arithmetic skills. The levels contain the following units:

Level A - addition, subtraction, whole numbers.

Level B - addition, subtraction, multiplication, division, whole numbers, fractions.

Level C - addition, subtraction, multiplication, division, whole numbers, fractions, decimals.

An earlier version of this program was prepared by WICAT Incorporated for Science Research Associates and is now being successfully marketed by that organization.

There are three operational modes in the program:

Placement mode. This mode is used to determine where a student should start a unit. The student is given sample lessons of increasing difficulty until the current achievement level is identified. Alternatively, teachers may place students where they desire.

Progress mode. Once placed in a unit, a student automatically moves from lesson to lesson on the basis of performance. If the student scores 80% or better on a lesson then he or she is moved ahead. If the student scores 50% or less, he or she is given another chance; a second failure results in movement to a previous lesson or, in some cases, to a request to "see your teacher." Scores between 50% and 80% lead to repetition of the lesson. The student may also pass or fail by getting a certain number of consecutive exercises right or wrong.

Practice mode. Work in this mode is recorded but does not affect the students' standing as determined by progress mode. As an example, practice mode might be used to provide review to a student who has been absent from school for a few days.

Carefully designed, graphically oriented helps are provided throughout the curriculum. While working on an exercise or after entering an answer, a student may call for a help which is a short interactive instructional sequence that shows how to do the exercise. The help is obtained by typing the question mark key. The help will show a student, step by step, how to work the exercise that was on the screen when he or she asked for the help.

Learner Profile

Diagnostic information now available to the privileged few can be extraordinarily helpful to teachers, parents, and students in achieving success in learning. Yet the majority of children receive, if anything, group administered paper and pencil tests quite unlike the one-on-one tests used by today's experts. Such group tests do not tap the full range of important learner characteristics, and do not provide thorough interpretive feedback, let alone feasible suggestions for dealing with the results.

A breakthrough is now possible for children, because computers can make one-on-one testing of each learner's profile widely available. These computers are now being purchased by schools for computer-aided instruction and administration. They can also be programmed to follow established scientific principles in administering tests, scoring and analysis, and to print our reports and suggestions for feasible actions that teachers, students, and parents can understand and use.

WICAT has received private funding to begin a Learner Profile project to develop these capabilities. The goal of this project is to enable children, parents, teachers and staff to understand and use learner profile information. The benefits are:

* Students will know what to practice to improve as learners and be motivated by the opportunity to track improvement as it occurs.
* School staff will be able to identify learning disabilities early and, in many cases, remediate them.
* Teachers will have a positive alternative to judging and labelling children when the only problem may be a mismatch between a child's learning profile and predominant classroom teaching methods.
* School staff will be able to provide truly individualized education plans.

From a scientific standpoint, we can expect an order of magnitude increase in the accuracy, consistency, and usefulness of learner profile test data from computer-administered measurement. New kinds of tests are possible. The measurement and interpretation can embody new findings in Cognitive Science, Brain Sciences, and Artificial Intelligence. The data can be collected continuously in real school settings, instead of under contrived and costly temporary set-ups, and can be related to actual achievement data on school learning.

The opportunity for expansion of high-quality in-school research will multiply the benefits to the users of the learner profile:

* Differentiated profile scores will be measured and studied, to obtain information not available from global summary scores.
* Testing will occur repeatedly over the year as the child improves. It will be obtained under familiar computer learning conditions, and will replace costly, infrequent, and traumatic "test days."
* Interactive computers will introduce new forms of measurement not possible by any human tester--precise response times, learning decay over time, and complex, information-rich scoring beyond the mathematical ability of the average human tester.
* Laser videodiscs controlled by computers will permit selection from a file of up to 54,000 colorful visual images, motion sequences, and audio in two or more languages. Life-like, game-like, job-like test situations will make a new range of abilities and traits measureable, with enhanced motivation on the student's part.
* Norms on thousands of students will be obtained rapidly and at little additional cost once several well placed school computers are involved.
* The growth and change in abilities and preferences, over time, and with practice, will be revealed.

* The relationship of abilities and preferences to achievement in each key school subject area will be determined.

Currently the following nine tests have been developed:

Shape judging. This test measures the student's ability to differentiate between different shapes. It consists of four sections. The first is a shape matching task in which the student is asked to "find the shape which matches." The second section is a character reversal task much the same as existing tests for dyslexia. The third section is a visual conceptualization task in which the student is asked to "find the shape which has the same visual idea as the first." The last task is a set matching task in which the student is asked to "tell which set this shape belongs to."

Digit memory. This test measures the student's digit memory span. It is comprised of two sections, the first presenting digits for the student with no interference, and the second requiring the student to respond to several problems between the presentation of the digits and their entry into the answer portion of the test.

Location memory. This test measures the student's ability to remember a series of locations. These locations are presented sequentially, in strings of from two to eight locations, and the student is required to enter the locations sequentially.

Word memory. This test measures the student's ability to remember a series of words. The words are presented at the rate of one per second in strings varying from two to seven words. The student is then asked to enter the string of words in the same order that he saw them.

Word/shape judging. This test measures the speed and accuracy with which a student can look at a simple shape with a word inside it and tell whether the shape matches the word. There is a time limit which is reduced each time that the student correctly responds and increased each time he fails to respond by the time limit.

Shape recognition. This test is a straight-forward gestalt completion test. In the first section of the test, the items are presented in steps that allow the student to press a help key in the event that he has no idea as to the correct answer. There is less credit for responses after the initial presentation of the item. The second section of the test presents the gestalt items with no help available.

Word coding. This test presents "buried word" items, and requires the student to "decode" them, determine their meaning, and then tell whether each is true or false, for example: HANDSWEARSHOES. Items are presented forward, backward, up, and down, and response time is considered for each item, as well as the number correct. There is a time limit for each item.

Vocabulary. This is a straight-forward vocabulary test. It is composed of two sections, the first requiring the student to match a word to its nearest synonym, the second requiring the student to match a word to its nearest antonym. The test ejects a student if he misses four in a row, and keeps track of the number of items taken, as well as the number correct.

Shape memory. This test measures the student's ability to remember shapes. He is shown a series of forty shapes and asked for each, "Have you seen this shape before during these tests? Time to respond is also measured for each item.

All support for development of the learner profile has come from sources other than those supporting the Department of Education "Indian Project" discussed in this report. However and because of the scientific and practical importance of both projects, we have attempted to integrate products of the learner profile project with the "Indian Project" to the extent that existing time and resources allow. For instance, pilot studies with a small population of Indian children included Learner Profile experiences as well as experience with the WICAT curriculums described above. Discussion of these pilot studies follows.

PILOT STUDIES

Much of adaptation, development, and evaluation activities in this project are taking place at the Waterford School in the Utah Valley. The Utah Valley lies practically at the geographic center of the Indian population of the United States. Arapahoe, Goshute, Navajo, Paiute, Shoshoni, and Utes among others have reservations within 300 miles of the Utah Valley. Additionally, 600-800 reservation youths live during the school year with local families in the Utah Valley. There are also about 2,000 Indians permanently residing in the Utah Valley as well as 500-600 Brigham Young University students with young children. Geographically, then, the Provo-Orem, area is uniquely well situated for undertaking planning, pilot, and demonstration projects for Indian children.

Waterford School itself is a private laboratory school operated by WICAT Education Institute and located in Provo, Utah. Scientists, educators, computer professionals, and school personnel are all located in the same physical plant at Waterford School so that evaluations, curriculum development, and curriculum adaptations can be effected in an efficient and responsive manner.

Phase II of this project includes a formal, systematic evaluation of all the WICAT materials discussed above. This activity will be performed by bringing Indian students on placement or residing in the Utah Valley to Waterford School. The scope of this activity will depend on the amount of support received for Phase II. It was determined early that formal, systematic evaluation of appropriate scope could not be supported by the funds provided for Phase I, and this activity was not included in the final statement of work for Phase I.

However, it was later determined that some informal, limited duration acitivity of this sort could be performed in Phase I. Accordingly, we proceeded to do it. Data from this early, pilot testing are presented in the following discussion.

Three times a week, Tuesday and Thursday afternoon and Saturday morning, about 40 Indian children were brought to Waterford School in the period 19 April 1983 - 19 May 1983. On each of these occasions, the children remained at the school for about an hour working on the reading comprehension curriculum, the arithmetic curriculum, and the Learner Profile materials. A few children tried the paragraph comprehension section from the beginning reading materials, but data from this activity are too sparse to report. Sufficient data were obtained on 37 of the children to report here. The children were categorized in three ways: grade in school, there were children from 3rd, 4th, 5th, and 6th grade; sex; placement or residential. Nineteen of the 37 children were on placement. Of these, 10 were in the first year of placement, 7 were in their second year, one was in the third year, and one was in the fourth. Table 1 shows the number of children within each of these three categories. As the table shows, the "spread" of the children was fairly even within these categories.

Reading Comprehension.

Over the four week period of the pilot study the students accumulated an average of 107 minutes on the reading comprehension curriculum. Average time accumulated by the students in reading within the three categories of school grade, sex, and placement are shown in Table 2. Based on the times shown in Table 2, it appears that there is not much difference among the student's time, but that perhaps the girls and the residential students were a little more diligent than were the boys and the students on placement, respectively.

As described earlier, a student on the reading curriculum completes a story in one of three statuses: mastery status if more than 80% of his responses were correct, working status if between 50% and 80% of his responses were correct, and failed status if less than 50% of his responses were correct. Table 3 shows the average number of stories brought to mastery or working status by the students during the 4 week/12 session pilot study. Once again it appears that girls and residential students were more diligent in their work on the reading curriculum. However, the average number of story completions shown in the table may not reflect very well the success of students in the curriculum--these completions may only reflect the amount of time the students spent on the curriculum.

Table 1.

Allocation of the 37 students within each of the three categories.

Category						
	3rd	4th	5th	6th		Total
School Grade	10	11	8	8	=	37
	Boys		Girls			
Sex	16		21		=	37
	Placement		Residential			
Placement	19		18		=	37

Table 2.

Reading comprehension--average time (minutes) accumulated in the curriculum.

Category				
School Grade	3rd	4th	5th	6th
	120.7	98.9	105.5	104.2
Sex	Boys		Girls	
	89.4		121.0	
Placement	Placement		Residential	
	89.5		126.3	

Table 3.

Reading comprehension--average number of stories brought to working or mastery status.

Category				
	3rd	4th	5th	6th
School Grade	7.9	5.9	8.5	9.6
	Boys		Girls	
Sex	6.8		8.6	
	Placement		Residential	
Placement	6.2		9.5	

This possibility is reinforced by data shown in Table 4. These data attempt to show the average amount of time in minutes it took students in the categories shown to bring a story to mastery or working status. Notably the minutes reported here include time accumulated when a story is failed or when a student "escapes" from a story leaving it uncompleted. The data shown in Table 4 then are a reasonable reflection of students' rate of progress through the curriculum. The shorter time required to complete a story shown by older students, or students in higher grades, probably does not reflect greater success with the curriculum so much as the time it takes older students to work up to stories at an appropriate level of difficulty--older students may spend a little more time doing easier stories than do younger students. It is notable that despite the earlier noted diligence of the girls, the boys in this sample actually required about a minute less time to bring a story to mastery or working status than did the girls. The diligence of residential students, however, seems matched by their better rate of progress through the curriculum--again about a minute faster to bring a story to mastery or working status than the students on placement. These differences are not explained by the girls and placement students spending more time "shopping around" for stories. Exactly the opposite is the case--boys and residential students escaped from more stories than did the girls and placement students respectively.

Proportions of correct responses (i.e. proportions of total responses that were correct) may also be of interest. These data are presented in Table 5. Because these data are based on a large number of responses, they can be assumed to be reliable--small differences can be assumed to be "real," larger differences can be assumed to have some practical significance. One strik-

Table 4.

Reading comprehension--average minutes required to bring a story to mastery or working status.

Category				
	3rd	4th	5th	6th
School Grade	15.3	16.7	12.4	10.8
	Boys		Girls	
Sex	13.1		14.1	
	Placement		Residential	
Placement	14.4		13.3	

Table 5.

Reading comprehension--proportions of correct responses.

Category

School Grade	3rd	4th	5th	6th
	.69	.60	.72	.65
Sex	Boys	Girls		
	.67	.66		
Placement	Placement	Residential		
	.63	.69		

ing aspect of these data is the variation in proportion of correct responses across grade levels. There is a 12 percentage point difference across the four school grade levels, and this difference is probably large enough to be noticed by the students. What to attribute these differences to remains an open question. The variability may be due to small numbers of students in each of the school grade sub-categories. Data from Phase II should tell us more about this possibility. The difference of one percentage point between the correct response rate of boys and girls seems of little practical significance other than to indicate that from this standpoint boys and girls seem to be experiencing about the same level of success with the curriculum. The difference between residential students and those on placement is, however, a somewhat different matter. Here the difference is 6 percentage points, perhaps large enough to be noticed by students, but certainly indicating relatively greater success with the curriculum on the part of the residential students.

In summary, then, with respect to the reading comprehension curriculum, the following three observations may be appropriate. First, despite some variability among the four school grades, there appear to be no real trends in success or progress with the curriculum that might be due to age or years in school. Very probably the variability that arose in these data will disappear in Phase II with larger numbers of students and a more systematic sampling procedure.

Second, sex differences do not appear to be particularly significant with respect to success or progress with the curriculum. Girls appeared to be more diligent in that they accumulated more time and completed more stories in the curriculum, but boys achieved the same proportion of correct responses as the girls, and they took slightly less time to bring a story to mastery or working status. Despite occasional pronouncements in the research literature that girls do better than boys in elementary school reading, research in computer-aided instruction in elementary school reading has usually shown that girls and boys progress and achieve at about the same rate (cf. Fletcher and Atkinson, 1972). The same sort of finding emerges from the data in this pilot study.

Third, there were some practical differences observable between the students who were residents of the area (the Utah Valley) and students on placement. The residential students showed greater progress and success with the curriculum on every measure taken. However, placement itself does seem to make a difference. As can be seen in Table 6, dividing up the placement students into those who were on their first year of placement and those who had been on placement more than one year (7 out of 9 of the placement students were on their second year of placement) shows a clear superiority within the latter group for the number of stories brought to working or mastery status and the time they required to do so. Also the group of students who had been on placement for more than one year showed a correct response rate that was one percentage point higher than that showed by the first year placement students, but this difference is probably of little practical significance. Notably, however, the one student on 3rd year placement and the one student on 4th year placement had correct response proportions of .76 and .71 respectively.

Arithmetic

Data available for the arithmetic curriculum are similar to those available for reading comprehension with the notable exception of response rates--

Table 6.

Reading comprehension--results for students with one and more than one year on placement.

	1 year on placement	More than 1 year on placement
Number	10	9
Average accumulated minutes	90.6	88.2
Average stories in working or mastery status	3.4	9.3
Average minutes to achieve working or mastery status per story	26.6	9.5
Proportions of correct responses	.63	.64

there is no detailed trace of students' responses that would allow determination of correct response proportions or number of responses made per minute. Over the four week period of the pilot study the students spent about as much time on the arithmetic curriculum as they did in reading. Overall they accumulated an average of 106.2 minutes in the arithmetic curriculum. Average time accumulated by the students in arithmetic within the three categories of school grade, sex, and placement status are shown in Table 7. There is some significant variability in average time accumulated across school grade levels, but, as with similar kinds of variability across grade levels in reading, there seems to be no clear interpretation of this result other than to suggest that it will disappear with larger and more systematic sampling of students. As with the reading curriculum, girls seemed to be more diligent in attendance as is shown by their greater number of average minutes accumulated on the arithmetic curriculum compared with the boys. There does not seem to be any significant difference between placement and residential students with regard to average time accumulated in arithmetic. This result contrasts with that of the reading curriculum in which residential students accumulated significantly more time than did the placement students.

In the arithmetic curriculum, a lesson is "passed" if a student responds correctly to more than 80% of its items. Average number of lessons passed within the three categories of school grade, sex, and placement status are shown in Table 8. Again there is variability in the school grade category, girls passed more lessons than did the boys, and residential students passed more lessons than did the placement students.

Table 7.

Arithmetic--average time (minutes) accumulated in the curriculum.

Category				
School Grade	3rd	4th	5th	6th
	109.3	107.4	89.0	117.9
Sex	Boys		Girls	
	88.0		120.0	
Placement	Placement		Residential	
	106.8		105.5	

Table 8.

Arithmetic--average number of lessons passed.

Category				
School Grade	3rd	4th	5th	6th
	35.4	33.8	34.8	54.6
Sex	Boys		Girls	
	35.3		41.7	
Placement	Placement		Residential	
	36.5		41.5	

However, to get a better understanding of differential success among the sub-categories, effect of time on the curriculum needs to be leveled out. This is done for the data presented in Table 9, which shows the average number of minutes students within the three categories took to pass a lesson. As with the reading data, these averages take account of all the time each student spent working on the arithmetic curriculum--in other words, they reflect the amount of system time required to pass one lesson. In regard to these data, it seems reasonable to conclude that older students (i.e., the 5th and 6th grade students), boys, and residential students took less time to pass lessons than did younger students, girls, and placement students respectively. Since the curriculum emphasizes arithmetic basics, it may simply be easier for older students than for younger ones. This notion is reinforced by the fact that several of the 5th and 6th grade students completed one half of their lessons in Level B, which is intended for 3rd and 4th grade students. It appears, then, that the greater success and progress of 5th and 6th grade students observable in these data are artifacts and should disappear once procedures for presenting the curriculum are better set. However, the slightly higher success rates for boys and residential students may reflect real differences in these populations across all four grades.

Although no data can be presented concerning proportions of correct and incorrect response it is possible to consider number of lessons passed as a proportion of all lessons attempted. These proportions are presented in

Table 9.

Arithmetic--average number of minutes to pass one lesson.

Category				
School Grade	3rd	4th	5th	6th
	3.1	3.2	2.6	2.2
Sex	Boys		Girls	
	2.5		2.9	
Placement	Placement		Residential	
	2.9		2.5	

Table 10. The proportions presented appear to be quite stable within the categories. The low proportion of .83 among 4th grade students is in keeping with the earlier data showing the 4th graders to have the lowest number of lessons passed and the highest--although not by much--number of minutes to pass a lesson. Interestingly, the 4th grade students generally performed less well than did students from the other grades in reading comprehension. The 4th graders came from a number of different schools and classrooms. That they appear as a group to be less able than students in the other grades probably reflects nothing other than the "luck of the draw." In any case, the arithmetic curriculum does seem to do a good job of managing stable curriculum experiences for Indian students with a variety of backgrounds and abilities.

In summary, then, with regard to the arithmetic curriculum the following three observations may be appropriate. First, and just as in the case of the reading comprehension curriculum, there appear to be no real trends in success or progress with the curriculum that might be due to age or years in school. What variability there is will probably decrease in Phase II when more students and more systematic sampling procedures can be used.

Second, and again as with reading comprehension, sex differences do not appear to be particularly significant with respect to success or progress with the

Table 10.

Arithmetic--proportions of lessons passed out of all lessons taken.

Category				
School Grade	3rd	4th	5th	6th
	.88	.83	.88	.90
Sex	Boys		Girls	
	.87		.87	
Placement status	Placement		Residential	
	.87		.88	

curriculum. Again girls appear to be more diligent, but boys seem to do just as well as girls once they are in the curriculum. In the long run it will be interesting to see if the sex bias favoring boys' performance in arithmetic that generally appears in junior high school can be dampened by computer-aided instruction. Very probably the difference between Indian and non-Indian students can be leveled-off by computer-aided instruction given the rates of success shown here.

Third, the differences between placement and residential students in performance on the arithmetic curriculum appear to be small--and relatively smaller than those for reading. This may be due to the less frequent and simpler use of English language in the arithmetic curriculum. In any event, it seemed useful to view data on the arithmetic curriculum for first-year and more than first-year placement students to see if any effect of years on placement could be discerned for arithmetic. These data are shown in Table 11. Surprisingly they indicate consistent differences favoring the first year placement students. These results are difficult to account for since number of years on placement should improve both verbal and quantitative skills of students. However, with regard to quantitative skills, these results seem to indicate the opposite. Illumination and explanation of these results will have to await completion of Phase II of this project. In the meantime the notion that placement seems mainly to develop the English language skills of Indian students is reinforced by these preliminary results.

Table 11.

Arithmetic--results for students with one and more than one year on placement.

	1 year on placement	More than 1 year on placement
Number	10	9
Average accumulated minutes	115.8	96.9
Average lessons passed	42.4	30.0
Average minutes to pass a lesson	2.7	3.2
Proportion of lessons passed	.92	.79

Learner Profile

Precise information on the amount of time the students spent working on the Learner Profile was not recorded. However, the average times should be fairly close to those reported for reading comprehension and arithmetic. With regard to number of computer-aided tests taken, it should be noted that the Indian students were free to decide which tests to take when. None of the Indian students took all the tests, and different students took different tests. Over all each student took about five tests. The number of students who took each test are shown in Table 18. There are no strong qualitative comments to be made about these numbers. More than anything else they may reflect the order in which they appeared on the students' list of test choices.

It is interesting to compare the Indian students performance on these tests with the performance of Waterford students. Around 90 Waterford students in grades 2-8 also took these tests. The average age and school grade of the Waterford students were therefore slightly higher than they were for the Indian students. It should not be surprising then that the Waterford students scored higher on almost all the tests than did the Indian students in their pilot study. However, the magnitude and ranking of the differences are of interest. If the Indian students performed in a way qualitatively similar to the Waterford students then their average test scores should be generally lower but not differentially lower--the differences between the average scores for the two groups should be about the same across all tests. This, however, is not the case.

Table 18

Numbers of students who took each Learner Profile test.

Test	Number
Shape Judging	26
Digit Memory	
Digits - with interference	7
Strings - with interference	7
Digits - without interference	20
Strings - without interference	20
Location Memory	
Rooms	19
Strings	19
Word Memory	
Words	11
Strings	11
Word/Shape Judging	21
Shape Recognition	5
Word Coding	16
Vocabulary	
Synonyms	9
Antonyms	8
Shape Memory	4

The difference between the two groups on each of the tests are presented as T-scores in Table 19. The differences are calculated by subtracting the average scores of the Indian students from the average scores of the Waterford students so that a positive T-score represents higher average scoring by the Waterford students. As the table shows the range of differences is large and does not reflect scoring by the Indian students that is uniformly lower by a simple, constant amount. For instance, the digit memory tests with interference may be relatively easier for Indian students than the digit memory tests without interference. Also, word memory for strings may be relatively easier for Indian students than word memory for words. Finally, it is notable that the Indian students out-performed the Waterford students on one test, Shape Recognition. It will be interesting to see if the same pattern of scoring emerges in Phase II.

Curriculum Recommendations

The discussions of curriculum recommendations that follow fall into two general sections, one concerning adaptation of the existing materials and one concerning development of new materials. The comments on curriculum adaptation are mainly based on observations of the Indian students who participated in the Spring pilot study and are fairly general in that they concern at least two and usually all three of the areas considered--reading, arithmetic, and Learner Profile. The comments on curriculum development are mainly based on the two surveys of the difficulties Indian students may have with English (Fletcher, 1983a) and with mathematics (Fletcher, 1983b) and are specific to these two curriculum areas.

Table 19

Differences between Waterford and Indian students scoring on Learner Profile Tests.

Test	T-Score	Degrees of Freedom
Digit Memory (Digits, w/o Interference)	7.88[a]	109
Digit Memory (Strings, w/o Interference)	7.14[a]	109
Word Memory (Words)	6.81[a]	89
Word Memory (Strings)	4.00[a]	89
Shape Judging	3.68[a]	114
Digit Memory (Digits w/ Interference)	2.88[a]	94
Vocabulary (Synonyms)	2.78[a]	98
Word Coding	2.78[a]	100
Location Memory (Strings)	2.76[a]	97
Digit Memory (Strings w/ Interference)	2.13[a]	94
Word/Shape Judging	1.97	106
Location Memory (Rooms)	1.06	97
Shape Memory	.86	93
Vocabulary (Antonyms)	.72	94
Shape Recognition	-1.79	95

[a]Significant ($p < .05$, two tailed)

Adaptation

Although the recommendations made here are based on experience with the Indian students in the Spring pilot study they are appropriate for all students. Nonetheless, their importance was emphasized by results from the pilot study. The recommendations center on seven issues:

Advisor functions. Both curriculums and the learner profile begin by presenting students with a menu of choices. However, little information is given to the students on which they can base a choice among the items presented. This was found to be a minor problem for the Waterford students but it emerged as a major problem for the Indian students who were caught in a double bind of having insufficient information on which to base a choice and being reluctant to make a choice without it. Some of the Indian students spent several minutes simply staring at the menus every time they were presented. It is clear that to be used successfully with Indian students, among others, the computer materials will have to include an advisor function that will recommend appropriate choices for students when they are presented with menus. At the least, this function should provide general information on which the students can base their choices.

In reading, current plans are to provide for each student an estimate of the level of difficulty of the "editions" displayed in the Newsstand. The student will also be given information about his or her status--mastery, working, or not passed--in the stories in editions he may be considering. In the Learner Profile, as noted earlier, the Indian students tended to start with the first test on the list and then simply take the rest of the tests in sequential order. Current plans are to provide an advisor function that will recommend subsequent tests to students based on their performance in prior tests and on some calibrating materials that may be given before the students begin working in the specific tests of the Learner Profile. In arithmetic the problem of choosing among alternatives was not difficult for any of the students. This may well be because the choices in the arithmetic curriculum are among relatively familiar sorts of items--addition, subtraction, division, whole numbers, etc. The Indian students in particular did not take overly long to decide among the arithmetic alternatives, and over the period of the pilot study their choices were fairly well spread among the alternatives. Finally, there already is in the arithmetic curriculum a limited advisor function in that students are told the number of the lesson they will be given within each of the alternative choices thus providing them a measure of their progress. For these reasons, there are no current plans to augment the advisor function of the arithmetic curriculum.

Introductory lessons. Although the student/computer interactions in the two curriculums and the Learner Profile were designed to be as simple as possible, many students, Waterford students as well as Indian students, experience occasional difficulty in telling the computer what they want to do. This difficulty seems to be a function not so much of the students forgetting how to interact with the computer as of learning the interactions in the first place--once the interactions are learned the students rarely forget them. The current procedure to solve this problem is to provide as much adult help as possible on the first one or two days students use the computer and to leave them on their own thereafter, with the exception of the computer room procotor who is always available to answer student questions. This procedure may not be sufficient. The recommendation in this regard, therefore, is to provide for each of the interaction types in the two curriculums and the Learner Profile a simple introductory lesson. These lessons should lead each student through the required interactions on a response by response basis in a way similar to the procedure now used by the computer room proctor in first introducing the students to the computer. In the Learner Profile materials, these lessons will have the additional benefit of providing an opportunity to "calibrate" students so that an advisor function can provide appropriate recommendations when students begin to take the Learner Profile tests.

Procedural helps. A great deal of help is provided with the content of the curriculum materials presented in the reading and arithmetic curriculums. However, the procedural helps, that is to say the helps intended to aid students in telling the computer what they want to do, may be insufficient. In reading, the information needed by a student for procedures of this sort is always presented at at the bottom of the display screen. Therefore, the procedural help for reading may need to be little more than a reminder to the student that this information is available and perhaps a slight expansion on the information given. In arithmetic, procedural helps in the form of reminders that students can ask for help, indicate "carries," select specific items on the screen, etc. should be provided. To some extent the need for these procedural helps may be obviated by the development and presence of introductory lessons for the interactions. Whether this is true or not will have to await empirical tryout of the materials in Phase II.

Knowledge of results. Both curriculums and the Learner Profile provide feedback to the students on their performance after they have finished a story, lesson, or test. However, it seems additionally useful to recommend two more procedures for providing knowledge of results to students. In reading when students "escape" from a story before finishing it some information about how well they are doing should be provided before the students leave the story completely. Displays for this new escape function have been specified and are illustrated in Figure 1. Figure 1a illustrates a display to a student who has escaped out of the story in which he is doing well. Figure 1b illustrates a display to a student who has escaped out of a story he could still pass. That is to say he could still achieve a level of 50% correct, which is required to reach working status in a story, but he or she could not get the 80% level of correct responses, which is required for mastery status. Figure 1c illustrates a display to a student who has escaped out of a story in which he or she could no longer reach either mastery or working status. In the Learner Profile materials, it is recommended that knowledge of results for some items be given at the time of the students' response rather than after he or she has finished all the items to the test. Exactly which tests should include this feature will have to await further data analysis, but it appears important to include it in at least some of the tests.

Audio enhancements. Some use of the audio capabilities seems to be indicated for both the reading comprehension curriculum and the Learner Profile materials. In addition to the pedagogical value of including audio enhancement in reading comprehension materials intended for those who must learn English as a second language there seems to be a more compelling socio-psychological reason. Students who are in the early, beginning reading materials use headphones because the beginning reading curriculum makes extensive use of audio. As it is now, when students move from the beginning reading materials to the read-

Figure 1. Displays for Escape Function in Reading Comprehension

YOU HAVE TRIED:
5
YOU HAVE CORRECT:
5
TOTAL IN STORY:
27

YOU CAN STILL MASTER THIS STORY.

DO YOU STILL WANT TO ESCAPE?
Y or N

Figure 1a.

YOU HAVE TRIED:
5
YOU HAVE CORRECT:
0
TOTAL IN STORY:
27

YOU CAN STILL PASS THIS STORY.

DO YOU STILL WANT TO ESCAPE?
Y or N

Figure 1b.

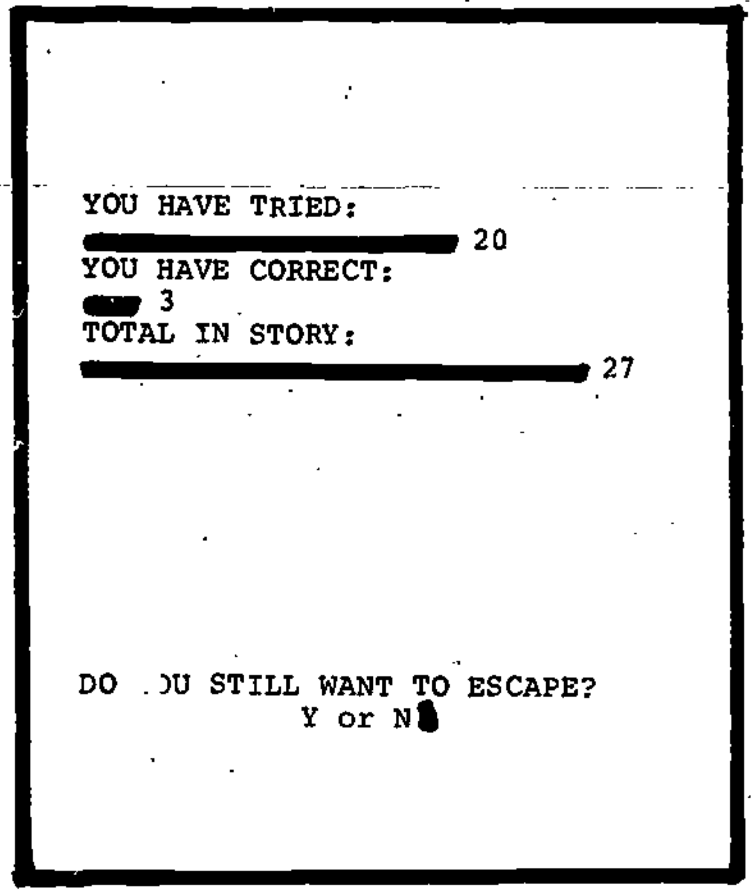
YOU HAVE TRIED:
20
YOU HAVE CORRECT:
3
TOTAL IN STORY:
27
DO YOU STILL WANT TO ESCAPE?
Y or N

Figure 1c.

ing comprehension materials they can simply take their headphones off. As a result, there is a very obvious way for all in the computer room to know who is doing well and who is doing poorly in reading simply by seeing who is wearing headphones and who is not. The solution seems to be to enhance the reading comprehension materials with audio both for its obvious pedagogical value and for this latter social value. In the Learner Profile, audio enhancement is more of a research issue. However, it is clearly an area of investigation that ought to be pursued, if for no other reason than to provide non-native speakers of English instructions in their native tongue.

Role commitment. One very obvious difference between the Indian students and the Waterford students grows out of an issue that is entirely separate from educational and/or ethnic background. This issue concerns the commitment of students to participating in what is an imperfect and experimental educational environment. The imperfections mainly concern procedural issues such as scheduling the students properly, accounting for machine "down time," coping with new materials and interaction types, and occasionally dealing with professional researchers who may not have the same level of expertise in interacting with children as do professional teachers. A great deal is done at Waterford to secure from both students and teachers a commitment to learning and achieving in an environment of this sort. As a result the Waterford students and faculty are very resilient in dealing with the sort of problems that arise in an experimental educational environment such as the one at Waterford. The same sort of resiliency was not displayed by the Indian students. It is doubtful that this lack of resiliency has anything to do with underlying and genuine characteristics of Indian students. Rather, it seems to reflect an insufficient effort on the part of project staff to secure a role commitment from the Indian students equivalent to that evident among the Waterford students. It should be emphasized that this was not a debilitating problem and these comments about role commitment on the part of Indian students should not denigrate the achievements of the Spring pilot study. This study was a successful and rewarding experience for all concerned. Nonetheless, it was also clear that project staff could and should do more to secure role commitment from Indian students as the project proceeds into Phase II.

Special education considerations. The private and relatively culture-fair features of computer-aided instruction have been noted many times in the research literature. These features were among some of the main reasons for undertaking this project. However, these features may be even more important with regard to special education. About half way through the pilot study, one of the parents of one of the Indian students reported somewhat sheepishly to project staff that her child had been placed by the public schools in a special education class for students who are creating disciplinary problems. This information came as a complete surprise to project staff since the particular student in question had been one of the most steady and diligent workers on the computer-aided materials. The experience left a subjective impression of the immense promise of computer-aided instruction in dealing with students who find it difficult to cope with the social-psychological trappings of classroom experience. The success of computer-aided instruction used in special education has been documented by a number of researchers, including Fletcher and Suppes (1975) with hearing-impaired students and Colby (1967) with autistic students. In any event, it is recommended that the promise of computer-aided instruction in reaching special education students, and in this case special education students from Indian populations, should be vigorously pursued.

Curriculum Development

In addition to the adaptation and modifications discussed above some development of new materials is necessary. Recommendations for development are made separately for the reading and arithmetic curriculum. These recommendations for development are primarily based on the surveys of English and mathematics completed earlier for this project. How much development can be undertaken and completed in this project will depend on Phase II and Phase III funding. The following recommendations discuss what should be done if the support can be obtained to do it.

Reading development. Based on information now at hand, there are 12 recommendations to be made for development of additional reading materials for Indian students:

* Materials should be developed that provide practice with selected minimally contrasting vowel pairs. Based on studies by Cook and Sharp (1966), Young (1968), Zintz (1971), Saville-Troike (1974), and Edwards (1981), practice using both computer text and audio capabilities should be provided with the following vowel pairs:

  /ə/ - /æ/

  /ə/ - /e/

  /ə/ - /a/

  /æ/ - /e/

  /æ/ - /a/

  /e/ - /a/

This practice should be provided in three ways, which are roughly graduated in difficulty. First, the pairs should be presented in monosyllabic words where the task is to determine if audio "spoken" by the computer is the same as or different than a monosyllabic word displayed as text. Second, the student should determine if two monosyllabic words "spoken" by the computer audio are the same or different. Third, the student should select the correct monosyllabic word from among several auditorically similar words displayed as text on the basis of an audio cue "spoken" by the computer.

* Materials should be developed that provide practice with selected minimally contrasting consonant pairs. Again based on studies by Cook and Sharp (1966), Young (1968), Zintz (1971), Saville-Troike (1974), and Edwards (1981), practice using both computer text and audio capabilities should be provided with the following consonant pairs:

/p/ - /b/

/t/ - /d/

/k/ - /g/

/ð/ - /θ/

/f/ - /v/

This practice should be provided in the same ways as it is for the minimally contrasting vowel pairs in the first recommendation. That is to say there should be two same/different tasks to determine first if audio "spoken" by the computer is the same or different than a monosyllabic word displayed by the computer as text and to determine second if two monosyllabic words "spoken" by the computer are the same or different. Third, again, the student should select the correct monosyllabic word from among several displayed as text on the basis of an audio cue "spoken" by the computer.

* Materials should be developed that provide practice with final consonants and consonant clusters. The final consonant clusters of English are too numerous to list here, but based on studies by Cook and Sharp (1966), Saville-Troike (1974), and DuBois (1979), practice using computer text and audio should be provided with final consonant clusters including those that arise from English plural and possessive forms.

This sort of practice is already provided by the spelling pattern exercises in the beginning reading materials. However, these materials do not include practice with plural and possessive forms. These forms should be added to the existing materials.

* Materials should be developed that provide practice with phonemes that do not exist in some American Indian languages. According to Young (1968) and Saville-Troike (1974), the following phonemes do not exist in Athapaskan languages: /f/, /v/, /r/, /ʒ/, /θ/, and /ŋ/.

Practice with these phonemes should be provided using the two same/different tasks and the recognition task described in the first two recommendations. For that matter practice with /f/, /v/, and /θ/ are already included in the second recommendation. Only practice with /r/, /ʒ/, and /ŋ/ need be added.

* Materials should be developed that provide practice with plural and singular noun forms. Since, as DuBois (1979) pointed out, many American Indian languages do not employ different singular and plural noun forms, practice with these forms, particularly the irregular forms ought to be provided.

To some extent this practice is already available in the word pattern and vocabularly exercises. However, some exercises that explicitly show the link between plural and singular noun forms should also be provided. These should be of two forms: recognition and production. The recognition exercises should require the student to select the correct plural form of a noun from among a list of possibilities after receiving the singular form as both an audio and textual cue. The production exercise should require the student to type in the correct plural form of a noun--a form he or she already can recognize successfully in the previous exercise--after receiving the singular form as both an audio and textual cue. Going the other direction, from noun plurals to their singular forms, is judged to be of substantially less value. However, this issue remains moot and some empirical work might well be undertaken to determine if this judgement is correct.

* Materials should be developed that provide practice with verb tense forms. Cook and Sharp (1966), Mickleson and Galloway (1969), and Wolfram, Christian, Leap, and Potter (1979) all reported problems with English verb tense forms. English irregular forms should be emphasized along with--'(e)s, '--'(e)d,' and--'ing' endings.

Practice with these materials should be provided in exactly the same ways described in the previous recommendation for plural and singular noun forms. That is to say recognition and production exercises should be developed that require students to recognize correct verb tense forms and--once recognition is achieved successfully--to produce the correct verb tense forms.

* Practice with English determiners should be provided. As Cook and Sharp (1966), Young (1968), and Edwards (1981) pointed out, count nouns with 'the,' 'a,' and 'an' in which definite versus indefinite determiners are contrasted cause considerable problems for American Indian students.

To some extent, this practice is already provided by the existing sentence comprehension and paragraph comprehension exercises. However, some materials that explicitly contrast definite and indefinite determiners should be included in these exercises and comprehension questions should be devised that highlight the contrast.

* Practice with third person singular pronouns should be provided. Cook and Sharp (1966), Young (1968), and Edwards (1981) all reported difficulties as American Indian students attempted to distinguish among masculine, feminine, and neuter gender in the third person singular.

Practice with these materials should involve matching sentences using the correct third person singular pronoun with a line drawing illustrating the sentence. The interaction required for this practice has already been prepared for the vocabulary graphics exercise. What is needed is the production of items that focus on third person singular pronouns.

* Practice with the semantic implications of juncture should be provided. Zintz (1971) indicated juncture as a problem for American Indian students, and contrastive exercises using computer audio to show the semantic implications of juncture should be included.

This practice should be provided in a straight-forward recognition exercise in which syllable pairs that contrast in meaning based on juncture are "spoken" by the computer audio to the student who must then select the correct textual representation of the audio.

* Practice with prepositions, verb-preposition combinations, and English idioms should be provided. Studies by Cook and Sharp (1966), Richards (1970), and Edwards (1981) all indicated the value of this type of practice.

This practice is already provided to some extent by the sentence comprehension and paragraph comprehension exercises. More items focusing on prepositions, verb-preposition combinations, and English idioms should be developed and included in these comprehension exercises.

* Practice with passive and wh-# transformations should be provided. Witherspoon (1977) and McCarty (1980) indicated these as problems for American Indian students.

Practice with comprehension of these transformations is already provided in the sentence and paragraph comprehension exercises. However, some direct practice in making these transformations, and their associated de-transformations, should also be provided. In these exercises the entire transformed sentence, or de-transformed sentence, should not be typed in by the student. The student should only be required to produce the correct verb form for passive transformations or the correct wh-# form for wh-# transformations.

* Basic vocabulary practice ought to be provided. Studies by O'Neale and Dolores (1943), Philion and Galloway (1969), Richards (1970), Kersey and Fadjo (1970), Young (1974), and Clifton (1976) all point to the value of this type of practice.

  This practice is already provided by the beginning reading curriculum, and, with the exception noted above, is probably sufficient. However, some basic vocabulary practice of the same sort ought to be included in the reading comprehension program as well. The same exercise types should be used, but the vocabulary levels should be appropriately adjusted for use by upper elementary and junior high school students.

Arithmetic development. Based on current information, there are two recommendations to be made for development of additional arithmetic materials for Indian students:

* Materials should be developed that provide practice on mathematics terms and concepts. Following the recommendations of Rosier and

Holm (1980) and Bacon, Kidd, and Seaberg (1982) for a bilingual approach, explanations of these terms and concepts ought to be made in American Indian languages, using computer audio capabilities, as well as in English. Some of the terms identified by Garbe's studies (1973, 1978) and by Moore (1982) should be explicitly taught and practiced. Finally, stochastic notions of probability and certainty as discussed by Philipsen (1972) should be explicitly taught, perhaps sooner than they would ordinarily be in a non-Indian oriented arithmetic curriculum.

To some extent terms and concepts, as well as notions of probability and certainty, are taught in some new mathematics materials developed for 7th and 8th grade. However, these terms and concepts are at junior high school level--they are not the simpler terms and concepts targeted by Garbe's work--, and there is no use of computer audio capability to pronounce and explain the term in English or in Native American languages. The vocabulary exercises from the beginning reading curriculum--particularly the vocabulary graphics and vocabulary meaning exercises--are well suited to the sort of mathematics vocabulary practice needed. These vocabulary exercises, then, should be adapted from the beginning reading curriculum, provided with the appropriate mathematics vocabulary items, and set-up as a separate strand in the arithmetic curriculum for use by students at all levels grades 1-8.

* Some practice with time estimation tasks should be included. In the light o[illegible] [illegible]ies by Mickleson and Galloway (1973), Anderson, Burd, Dodd, a[illegible] [illegible]ker (1980), and Burd, Dodd, Smith, and Grassl (1981), it appears that some units should provide practice in estimating time

needed to complete fairly common (to American Indians and others) tasks. The problem uncovered by these studies may be one of difficulty in breaking down tasks into their components and seeing the sequence of events needed to accomplish the tasks as well as estimating time for them. Providing practice in the techniques of problem solving analysis may be a significant step in helping American Indians acquire coping skills needed for modern society, and time estimation skills may be the best vehicle for this process.

This practice should be developed and set-up, again, as a separate strand in the arithmetic curriculum with levels of difficulty appropriate for students at all levels, grades 1-8. Graphics should be used to aid students in visualizing the tasks to be done and in breaking down the tasks into components whose durations or time requirements are more easily estimated.

* The computer presented materials should capitalize on the inherently motivating "gaming" capabilities of computer interaction. The appeal of using video gaming techniques to teach relevant and appropriate subject matter is hard to deny. The probability that this could be done successfully for mathematics instruction is very high. If Green (1978) is right and the primary obstacle to mathematics success among American Indian students is one of attitude, then the use of a gaming approach to teach mathematics to American Indian students seems almost mandatory.

The best way to satisfy this recommendation would be to develop an "intelligent," or computer-controlled, videodisc that took a problem solving approach to teaching mathematics. Students would then be put int a visually rich environment in which they learned and used mathematics as a way to solve problems--or win games. However, funding for this project will not support development of a videodisc in addition to all else that must be done. Nonetheless the spirit of what is suggested here can be captured to some extent by a problem solving environment created on a computer alone. This sort of development should be attempted on an experimental basis in this project.

FINAL COMMENT

The discussion here is, of course, more tentative and perhaps tantalizing than final. However, three conclusions do seem to be warranted based on project experience thus far.

First, it seems reasonable to conclude that the WICAT reading, arithmetic, and Learner Profile materials can be used successfully and profitably by Indian students. In the approximately 12 sessions students spent on the computer materials during the Spring pilot study, they passed on the average about 8 reading stories, 37 arithmetic lessons, and completed about 5 Learner Profile tests. The Indian students responded correctly about 67% of the time in the reading curriculum, and they passed about 87% of the arithmetic lessons attempted. As mentioned above, the Spring pilot study was a rewarding experience for all concerned, and there seems little reason to expect widely different results from different populations of Indian students.

Second, some modifications of procedures for presenting the materials will make them easier to use. These modifications primarily concern better preparing students to interact with the system, i.e. providing more introductory and follow-on information to the students on the procedures for communicating with the computer. These modifications include the provision of advisor functions, introductory lessons, procedural helps, knowledge of results, and audio enhancements as well as more focused efforts to secure role commitment from the students.

Third, some development of new materials specifically for Indian children will substantially enhance the pedagogical power of the reading and arithmetic curriculum materials. Twelve recommendations for new reading materials and three recommendations for new mathematics materials were documented.

In addition to these conclusions, several results from the Spring pilot study deserve further consideration. For instance, it will be important to determine in Phase II if the following results hold up:

* There were no sex differences in performance by boys and girls on reading and arithmetic. That is to say, and contrary to occasionally documented expectations, there was no observable superiority in girls' performance on reading or in boys' performance on arithmetic.
* There were no performance trends observable in reading as a function of school grade, and the trends observable in arithmetic may be completely explained by procedures for presenting the curriculum--not the curriculum itself. Generally speaking proper management of the materials should prevent these trends from appearing.
* There were placement versus resident status effects in reading. Residential students generally did better than placement students

in reading. This effect was also observable in shorter times to complete stories by students who had spent more than one year on placement than by those in the first year of placement.

* There appeared to be little effect of placement versus residential status on performance of students in the arithmetic curriculum. However, when the placement students were partitioned into first year and more than first year placement groups, the students who were in the first year of placement out-performed the students who were in subsequent years of placement.

* Different Learner Profile tests were of different relative difficulty for Indian and Waterford students. These differences were especially observable in the Digit Memory and Word Memory tests. Differences were also observable in the Shape Recognition test on which the Indian students achieved higher scores than the Waterford students.

In short, the work and results documented above appear to be a worthwhile beginning--but only a beginning. More systematic and complete sampling of Indian students for follow-on pilot study is needed to resolve issues that were noted above or are likely to appear with the introduction of new curriculum materials. However, the notion that computer-aided instruction has substantial potential to increase the productivity of our educational institutions in instructing Indian students in the education basics was both confirmed and reinforced by the work of this project. Computer-aided instruction has both promise and challenge for the Indian education community. We should rise to the occasion.

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