DOCUMENT RESUME

ED 100 361 IR 001 460

AUTHOR	Dunn, Alex, Ed.; And Others
TITLE	Computer-Assisted Instruction Program. A Three Year Report Covering July 1, 1971 Through June 30, 1974.
INSTITUTION	Montgomery County Public Schools, Rockville, Md.
PUB DATE	74
NOTE	203p.
EDRS PRICE	MF-$0.75 HC-$10.20 PLUS POSTAGE
DESCRIPTORS	Administrative Problems; *Computer Assisted Instruction; Computer Graphics; Computers; Computer Science Education; Curriculum Development; *Educational Research; *Elementary Grades; Elementary Schools; Elementary Secondary Education; English; French; Grade 1; Industrial Arts; Junior High Schools; Mathematics; On Line Systems; *Program Evaluation; *Secondary Grades; Social Studies; Staff Improvement
IDENTIFIERS	CAI; Computer Literacy; Montgomery County Public Schools

ABSTRACT

The Montgomery County Public Schools Computer Assisted Instruction (CAI) Program began in 1968, was federally funded for its first three years, and since 1971 its activities have been supported through local funds and an outside grant covering the lease of the computer for the project. During the last three years validated CAI materials developed during the first phase of the project were placed in classrooms, and evaluation studies were undertaken. Although small instructional packages were developed during this period, most of the emphasis was on implementation of more than 40 modular instructional packages. CAI capabilities were extended to a junior high school and to a first grade classroom at one elementary school. The instructional objectives and CAI applications for each grade level and subject area are described in this report, as are the evaluation findings and suggestions for further research and development. Some comments on possible future directions for CAI in public schools are also included. (DGC)

Computer-Assisted Instruction Program

. THREE YEAR REPORT COVERING JULY 1, 1971 - JUNE 30, 1974
Y CATHERINE MORGAN/DIRECTOR/CAI PROGRAM AND
VILLIAM M. RICHARDSON/DIRECTOR/DEPARTMENT OF
ADVANCE PLANNING AND DEVELOPMENT/JAMES W. JACOBS/
ASSOCIATE SUPERINTENDENT/OFFICE OF PLANNING,
MANAGEMENT AND COMPUTER SERVICES/
HOMER O. ELSEROAD/SUPERINTENDENT OF SCHOOLS/
MONTGOMERY COUNTY PUBLIC SCHOOLS/ROCKVILLE, MARYLAND

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Computer-Assisted Instruction Program

REPORT EDITED BY ALEX DUNN

COVERING PERIOD FROM JULY 1, 1971–JUNE 30, 1974

BY
CATHERINE E. MORGAN
DIRECTOR
COMPUTER ASSISTED INSTRUCTION PROGRAM
WILLIAM M. RICHARDSON
DIRECTOR
DEPARTMENT OF ADVANCE PLANNING AND DEVELOPMENT

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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HOMER O. ELSEROAD/SUPERINTENDENT OF SCHOOLS
JAMES W. JACOBS/ASSOCIATE SUPERINTENDENT/**OPMCS**

Montgomery County Public Schools

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ACKNOWLEDGMENT

The Computer-Assisted Instruction Program continued operation beyond the termination of federal funding (June 30, 1971) because of the tremendous support provided by many enthusiastic and dedicated supporters. Harriet T. Bernstein, president of the Board of Education; the members of the Board; and Homer O. Elseroad, superintendent of schools, have contributed significantly to the program's continuing another three years. James W. Jacobs, associate superintendent for planning, management, and computer services, played a major role in the overall planning and shaping of the program's future course.

Much of the program's success is attributed to the members of the staff and to Thomas A. Conlon, Jr., and Frank G. Edwards, principals of Albert Einstein High School; Robert F. Redmond, principal of Newport Junior High School; Louis S. Monk, principal of Rock Terrace High School; and Richard B. Reese, principal of Pleasant View Elementary School. Ultimate success for the program rested with the teachers and students who used the modular instructional packages and participated in the research designs.

ABSTRACT

The past three years – 1971 through 1974 – might well be characterized as the years of "curriculum implementation and related research," for it has been during this phase that the Computer-Assisted Instruction (CAI) Program has placed its validated materials into the classrooms, and conducted comparative evaluation studies. Although small instructional packages continued to be designed in English, French, reading, and mathematics, primary emphasis was given to implementing the more-than 40 modular instructional packages developed at the program by educational technologists, trained in the design and development of instructional materials. Long range comparative evaluations, selected validations, and other extended research were also of paramount importance to the program's operation during this period as various studies were conducted in Montgomery County Public Schools. At the elementary level, a unique computer-managed instructional system was begun in a selected first grade at Pleasant View Elementary School. Two student terminals, including computer auditory components and light pens, were locat· ··ithin the classroom proper to provide reading, phonics, and arithmetic assessment at the compu erminals. This was the first time sophisticated computer equipment had been situated in a prima.y classroom, and educational specialists were concerned about the first graders' adaptability for operating the keyboard, light pen, and audio-head sets. However, the six-year olds quickly developed the necessary skills for communicating with the computer and used the computer terminals daily as part of their regular classroom activities.

A concerted effort, meanwhile, was continued by the director and staff members to keep educators and local citizens abreast of the ongoing and continuous research. More than 1000 representatives from educational institutions and private corporations in the USA and abroad visited the CAI Program offices or attended presentations by staff members. Many had the opportunity to observe students from first grade through senior high school interacting with CAI materials. Visitors included educators and technologists from as far away as Japan, Vietnam, and Denmark who came to view the time-sharing computer in the instructional process. Over 800 copies of the Program's 500-paged *Title III Final Report* were distributed in the USA and abroad during the past three years, and more than 300 copies of *Authoring Individualized Learning Modules: A Teacher Training Manual* were purchased by teachers and educational technologists throughout the world. Through a successful merging of computer technology and validated curriculum, the CAI Program has earned a reputation for professional achievement. Inherent in this recognition has come the responsibility to investigate fully the capabilities of the computer's role in the educational process and its viable function as a support to the teacher. Computer literacy was also a main thrust of the program's operation during 1972-1974, and packages were initiated at both the elementary and high school levels. A two-year time-sharing project involving nine Montgomery County high schools has been administered by the CAI Program.

Although few changes occurred in the hardware configurations during this phase, in the summer of 1972, computer facilities were extended to include Newport Junior High School, the third and final school of the original master plan of 1968. A small room at the junior high school was modified to accommodate seven student stations and one proctor station, all transferred from location at Einstein High School.

The program plans describe the recommendations which have been made to and approved by the Superintendent and the Board of Education based on research data and related experiences of the CAI Program. Finally, the document takes a look at the future when computer technology is an integral part of the regular instructional process in public schools.

INTRODUCTION

The Montgomery County Public Schools Computer Assisted Instruction (CAI) Program has been in operation since July, 1968. This report, however, covers only those activities extending from July 1, 1971, through June 30, 1974. As a program document, it summarizes the continuing research and curriculum development that has characterized the program since its beginning. Furthermore, it provides a description of how the curriculum, developed by Montgomery County teachers and teacher specialists, was implemented into the county schools. It should be noted that the program's first three years of operation, which were federally funded, have been extensively documented in a detailed 500-page report published in 1972 by Montgomery County Public Schools. Copies of that report are available from the program offices. It is the expressed purpose of this report to describe only those activities of the program which have occurred since the publication of the *Title III Final Report*. With the expiration of federal support on June 30, 1971, the CAI Program continued operation under local funding from Montgomery County Public Schools and an outside grant covering the lease of the computer.

The first three years were devoted mainly to training staff, developing curriculum, pilot-testing the materials, and conducting validation studies. Thus it was imperative that the program be continued in order to implement the developed curriculum on a broader scale and to design and conduct long-range comparative evaluations. The program goals for the period from July 1, 1971, through June 30, 1974, were as follows:

1. To evaluate the effectiveness of computer-assisted and computer-managed instructional systems with MCPS students

2. To develop and use CAI reading modules with primary students

3. To develop and validate mini-courses in computer literacy

4. To develop and validate a problem-oriented mathematics curriculum for pilot use with fourth grade students

5. To provide the use of MCPS-developed CAI modules for Adult Basic Education and High School Equivalency courses

6. To provide staff development training courses in educational technology and computer-assisted instruction for selected MCPS personnel

7. To provide MCPS teachers with individualized courses using CAI as the mode of instruction (The courses could be taken for university credit.)

8. To provide a resource center furnished with current articles, journals, and books on educational technology and computer-assisted instruction

This report documents those activities in which the staff engaged to meet the stated objectives. The evaluation of the effectiveness of CAI and CMI instructional systems has been a continuous and ongoing activity during the past three years. MCPS students have been involved at the elementary, junior high, and senior high levels. As planned, the program has also developed and used a computer-managed instruction system for first grade during the past two years. In addition, a new method of teaching reading using CAI has been designed and extensive related materials written. Although these modules have not yet been coded for the computer, programming of the reading modules is planned for the near future. Three computer literacy mini-courses have been developed and used with students; a fourth module is in the developmental stages. In addition, the program has developed and pilot-tested a problem-oriented mathematics curriculum with fourth grade students. Approximately 20 Adult Basic Education students used the arithmetic and English packages during 1973-1974 school year. Although the emphasis of the program during 1971-1974 was not on staff development, the CAI staff provided training in educational technology and computer-assisted instruction for more than 16 MCPS teachers. More than 40 teachers were enrolled in CAI courses for university or in-service credit. Finally, the CAI Program established a resource center furnished with articles, journals, and texts on educational technology and computer assisted instruction. Extensive use has been made of this facility which is available to all MCPS teachers and teacher specialists.

A continuing responsibility of the CAI Program has been to make recommendations based upon the results of evaluations. During 1974, recommendations on the extension of computer-assisted instruction and computer-managed instruction, entailing a new computer language and hardware, were submitted to the Superintendent and Board of Education. This plan, which was accepted and approved, will extend computer services into a total of 20 Montgomery County public schools by 1975.

I. OPERATIONAL CAI AND CMI CURRICULA

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The documentation for most of the operational curricula appears in the CAI Program's *Title III Final Report* of June 30, 1971. Only those programs which have undergone extensive and significant revisions are repeated in this document. Authors of these programs felt that the changes made were of such magnitude and importance that the entire program as revised should be included.

With computer-assisted instruction available as a support to instruction, learners and teachers assume new roles. The student must be more responsible for his own learning. The teacher becomes the manager of the instructional process, providing counseling, guidance, and tutoring to help students reach necessary objectives.

As the terms *computer-assisted instruction* (CAI) and *computer-managed instruction* (CMI) are used extensively throughout the report, it is important that these in-house definitions be included. Computer-managed instruction as defined by the program is the use of computer terminals by students for diagnostic, prescriptive, and assessment purposes with no on-line instruction. Computer-assisted instruction, on the other hand, is the utilization of modular instructional packages which provide on-line instruction including tutorial, simulation, and drill and practice materials to assist students in attaining specific learning objectives.

It should be pointed out that computer-assisted instruction is primarily concerned with those learning processes related to instruction, while computer-managed instruction is most directly related to the processes of instructional management. In addition to the diagnostic, prescriptive, and assessment elements, computer-managed instruction provides teachers with the supports necessary for monitoring individual student performance by measuring, recording, and analyzing student attainment of specified learning objectives. Both CAI and CMI have assisted MCPS teachers in providing individualized curriculum for students.

The program's philosophy has been to aid instruction through the development of individual modules within specific subject areas. A program is developed only after the need for such a module is clearly identified, and it is determined that the CAI mode will be more effective than another method of instruction. Experience has shown that single modules, appropriately designed for use throughout a school year, are more flexible and receive wider usage by students than do year-long programs. While modules are usually designed for a specific target population, many programs are being used with a variety of student levels. Specifically, the elementary arithmetic programs are presently in use at the elementary, junior, and senior high levels and Adult Basic Education and with special education for the mentally retarded.

In an effort to optimize the benefits derived from CAI and at the same time meet the needs of Montgomery County students, it was necessary to make decisions regarding the emphasis of curriculum development. Three years' experience showed that the computer could assist the teacher in a number of ways, one of them being the development of basic skills. Long-range and comparative studies further supported this view. Thus the program emphasized acquiring and developing basic skills in specific areas such as reading, arithmetic, and phonics at the elementary level and mathematics skills at the secondary level. To execute this philosophy, it was evident that the program must have wide usage of curriculum materials in a variety of situations. In addition, experience had shown that CAI was most effective when the involved faculty, department heads, and local school administrators were committed to meeting individual needs of students and providing individualized instruction. Such an educational philosophy drastically changes the roles of both student and teacher. The teacher becomes the manager of the instructional process, providing counseling and guidance to assist the student in reaching his desired objective. Meanwhile, the student becomes more responsible for his own learning in a program that has been tailored to meet his own individual needs.

As adjustments were made in the area of curriculum development, no student use was made of the science modules during 1971-1974 although all programs are still intact. Whereas most CAI modules have the adaptability for use throughout a given academic year, most of the developed science programs are limited in their design for use at only specific points in a course. This section of the document, therefore, is devoted only to those modules which have received wide usage and/or revisions as a result of extensive usage.

During the original three-year funding period, a number of elementary programs were written by supporting teachers as part of their original training program. Subsequently, certain of these programs were evaluated and deleted from use for a variety of reasons. All materials which are developed or used at the program must be valid and acceptable, while at the same time effectively use the capabilities of the computer. PROJECT PERIMETER and EXPANDING NUMERALS AND WORD SEARCH did not meet the requirements of the CAI Program for one or more of the above reasons.

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A. ELEMENTARY

The Design Team

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Elementary teacher-authors meet to design instructional programs.

The design team of elementary school teachers responsible for developing CAI and CMI curricula is directed by Beverly J. Sangston, who came to the program in February, 1969, shortly after its initial funding. As a CAI specialist in curriculum design, Miss Sangston has taught, traveled extensively as a consultant, and conducted numerous demonstrations in CAI and CMI at the elementary level. She has provided educators and technologists with in-depth personal experiences gained from her four years of curriculum development and implementation at the CAI Program. The design team consists of five MCPS teachers identified through their involvement in one of the Teacher Training Programs. They are committed to the individualization of instruction and have demonstrated outstanding ability in designing curriculum using a systems approach to learning.

Ann Cummins, an original design team member, participated in the first Teacher Training Program in the fall of 1968. Through her work as a curriculum designer and her outstanding teaching performance, Miss Cummins was instrumental in the development and implementation of the computer-managed first grade program in September, 1972. The CAI Program placed two student terminals in her classroom for use in an individualized reading, arithmetic, and phonics (RAP) program. A description of RAP is included in this document under Developmental Curriculum.

Donna Kirsch, a supporting teacher with classroom experience at the second, fourth and sixth grade levels, authored the CAI Mathematics Program LEARNING ABOUT PER CENT (LAP). Her work with the elementary design team during 1971-1974 included writing the tutorial segment on Estimation, which has been included in the division section of OWN, and assisting with the revision of the entire OWN Program. Miss Kirsch, who was trained in a 1969 summer workshop, has participated actively in curriculum design since that time as a CAI supporting teacher. In the summers of 1971-1973, she taught the Individualized Review Mathematics class at Pleasant View Elementary School for fourth, fifth, and sixth grade students who used the CAI elementary mathematics packages.

Three additional elementary design team members were identified from the 1972-1973 Teacher Training Program and also contributed one day every two weeks to curriculum design and development: Donna Gullickson, Pleasant View Elementary fourth grade teacher, Laura Stoskin, Somerset Elementary sixth grade teacher, and Elissa Weinroth, Potomac Elementary fifth grade teacher. All are experienced classroom teachers with additional training and expertise beyond what is normally required of elementary school teachers.

Mrs. Gullickson earned a bachelor of arts degree at Western Maryland College and a master of education in Elementary Education at the University of Maryland. Although most of her teaching

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experience has been concentrated in the second, third, and fourth grades, she has also taught English and social studies at the junior high school level for two years.

Miss Stoskin, who took her bachelor of arts degree at the University of Massachusetts and her master of arts degree at Springfield College, has done graduate work at both Harvard University and the George Washington University. A wide range of teaching experiences in Grades 2–6 has provided her with valuable data for designing the CAI module LEAST COMMON MULTIPLE. She has supervised student teachers from two local universities, presented workshops in creative language, and taught a teacher competency course to MCPS teachers. Committed to a philosophy of individualization in her classes, Miss Stoskin has participated in MCPS workshops in differentiated instruction, independent contracting, individualized mathematics, and divergent thinking instruction.

Mrs. Weinroth, who earned both her bachelor of arts and master of arts at Brooklyn College, is pursuing a doctorate in educational administration at American University. She has taught Grades 1–5, supervised student teachers, and participated in numerous MCPS workshops. During the summer of 1974, she conducted the Young Authors Conference, a workshop in which children do creative writing and later participated in the Hayes-Fulbright Seminar for Visiting Teachers. Mrs. Weinroth was trained in the CAI Program's 1972-1973 Teacher Training Program and designed the package CONSTRUCTING PLURALS FROM COMMON NOUNS. Later she was identified as a supporting teacher and joined the elementary design team.

1. OPERATION WHOLE NUMBERS

OPERATION WHOLE NUMBERS, Version I, was used with students in elementary school, senior high school, special education, and adult basic education during 1969-1971. Group and student performance data was stored on tape and carefully analyzed to validate not only the sequence of the behavioral objectives in each operation but also the diagnostic and drill strategies used throughout the program.

Results of this analysis indicated to the author that no additional drills would be needed in multiplication and only minor revisions were needed in addition and subtraction. The division section, however, would have to undergo major changes before it could be considered completely acceptable.

An accumulation of data showed that some students could pass drills based upon single objectives by observing answer patterns. Therefore, review tests with randomly generated problems from several drills were inserted throughout each operation.

Changes in the addition section of the program consist of six additional enabling objectives, each of which involves computation with three addends. Indications were that students needed a greater exposure to the manipulation of three addends, with or without regrouping, to reach the terminal objective.

In subtraction, two additional enabling objectives were added to the sequence of skills leading to the attainment of the terminal objective. These new levels provide the student with additional experiences in regrouping and subtracting from zeros.

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The division section now consists of 61 behavioral objectives. The first 46 have one-place divisors and have been consolidated into 19 drill levels. The remaining 15 objectives for which a drill level exists for each have two-place divisors. Three tutorial modules were developed to teach the rounding and estimation skills needed for division with two-place divisors.

A diagnostic placement test identifies the appropriate level of entry. When a student meets the criteria for success in one-place divisors, he begins a diagnosis in two-place divisor computation. Once the student completes all the drills, he takes a posttest on the four terminal objectives of the program.

A detailed documentation of the objectives, hierarchies, strategies, and tests in OPERATION WHOLE NUMBERS, VERSION II, appears on the following pages.

Description

OPERATION WHOLE NUMBERS, VERSION II, combines the CAI techniques of diagnostic testing, drill and practice, and tutorial dialogue in a program designed to strengthen a student's computational skills in each of the four basic operations of whole numbers. The program was designed for intermediate and upper elementary students but has also proved useful with students in special education, adult basic education, and tenth grade mathematics.

The student progresses through a controlled sequence to attain the four terminal objectives:

1. Given an addition problem with 3 three-place numerals presented vertically, the student constructs the sum, regrouping in ones, tens, and hundreds places required.

   Example: $\begin{array}{r} 986 \\ 747 \\ \underline{+\ 568} \end{array}$

2. Given a subtraction problem presented vertically, the student subtracts a four-place numeral from a four-place numeral, regrouping in hundreds, tens, and ones required.

   Example: $\begin{array}{r} 9{,}284 \\ \underline{-\ 7{,}995} \end{array}$

3. Given a multiplication problem with one factor a three-place numeral and the other factor a two-place numeral presented vertically, the student constructs the product, regrouping required.

   Example: $\begin{array}{r} 763 \\ \underline{\times\ \ 25} \end{array}$

4. Given a division problem with a four-place dividend and a two-place divisor not a multiple of ten, the student constructs the two-place quotient and the remainder.

   Example: $83\overline{)6742}$

The content of OPERATION WHOLE NUMBERS is divided into four sections: addition, subtraction, multiplication, and division. Each section has three components: a pretest, a sequence of drills, and several review tests. The division section also includes tutorial segments on rounding two-place numbers to the nearest ten and on estimating quotients. A posttest on all four sections completes the program.

Pretest

A pretest consists of a survey test on the terminal objective of the program section and a network of diagnostic tests at specific drill levels to place the student at the appropriate level for computer-assisted drill or teacher instruction. The pretests for addition, subtraction, and multiplication are described in the following two paragraphs; division is described in the third paragraph.

Survey Test

To demonstrate proficiency in the terminal objective of the operation and pass the survey test, the student must answer four problems correctly. A maximum of five problems is presented. If the first survey test (addition) is passed, the student proceeds to the next survey test (subtraction). By passing all of the survey tests, he can complete the program. However, if he misses two problems in a survey test, he is branched to a basic fact test in addition and multiplication or to a diagnostic test in subtraction.

Basic Fact Test

The addition and multiplication basic fact tests include the 100 basic facts in each operation grouped in four sections according to difficulty. Student performance determines which of two possible paths the student takes through sections 3 and 4 to the diagnostic network or through sections 3, 1 and 2 to the drill sequence. Regardless of path, the student progresses through the sections by studying and learning facts missed and by being retested until he achieves 100 per cent.

Diagnostic Test

To pass a diagnostic test, the student must answer three problems correctly. A maximum of four problems is presented. If the student passes, the computer program will branch him to a diagnostic test of greater difficulty or to a drill at a higher level. If, however, the student answers two of the four problems correctly, he is put into a drill at that level. If he answers less than two problems correctly, he is further diagnosed with problems of lesser difficulty or is branched to his teacher for instruction.

Division Pretest

In the division pretest, the student begins with a diagnostic test at Level 13 in one-place divisors. Before typing in the answer to a division problem, the student must use the light pen to indicate the placement of the first digit in the quotient. If the student chooses correctly, a small answer box called a "cursor" appears, and the student types in the answer. If the cursor is misplaced, the problem is recorded as incorrect. If he passes with three correct answers, he proceeds to diagnostic tests at Levels 18 and 19. If he does not pass diagnostic 13 (or 18 or 19), he is further diagnosed and placed in the appropriate drill or branched to his teacher for instruction.

The student who successfully completes the one-place divisors pretest proceeds to division Survey Test A, which contains problems from levels 28 and 29. If he passes Survey A with four correct answers, he is given Survey Test B with problems from Level 34, the terminal objective. The student who does not pass Survey A is further diagnosed and placed in either a drill or instruction on rounding. The student who passes Survey A but does not pass Survey B enters the pretest on rounding and estimation and, according to his performance, is placed in the appropriate objective of the rounding or estimation tutorial segments. When the student completes the tutorial segment, he proceeds with the drill sequence.

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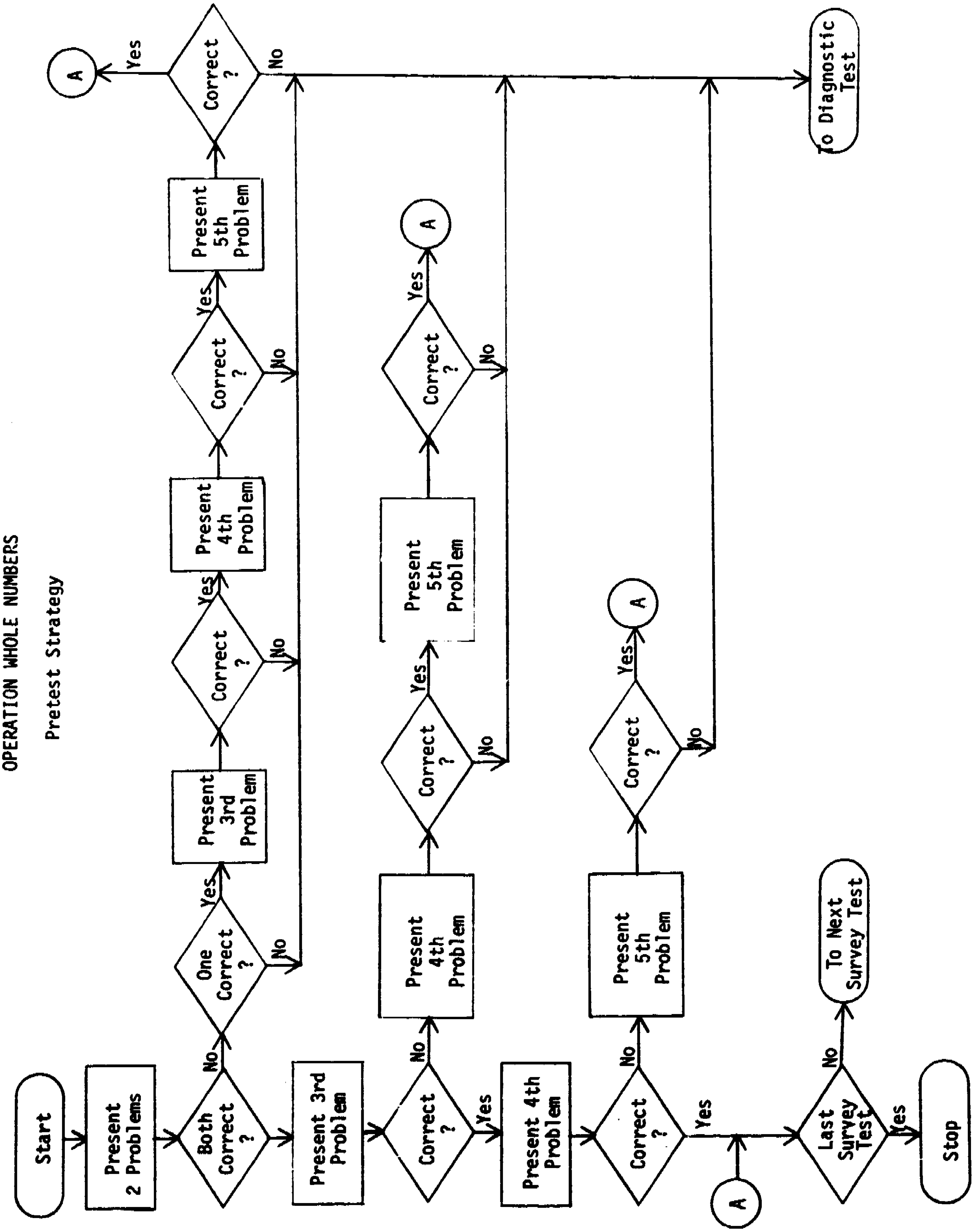
OPERATION WHOLE NUMBERS

Pretest Strategy



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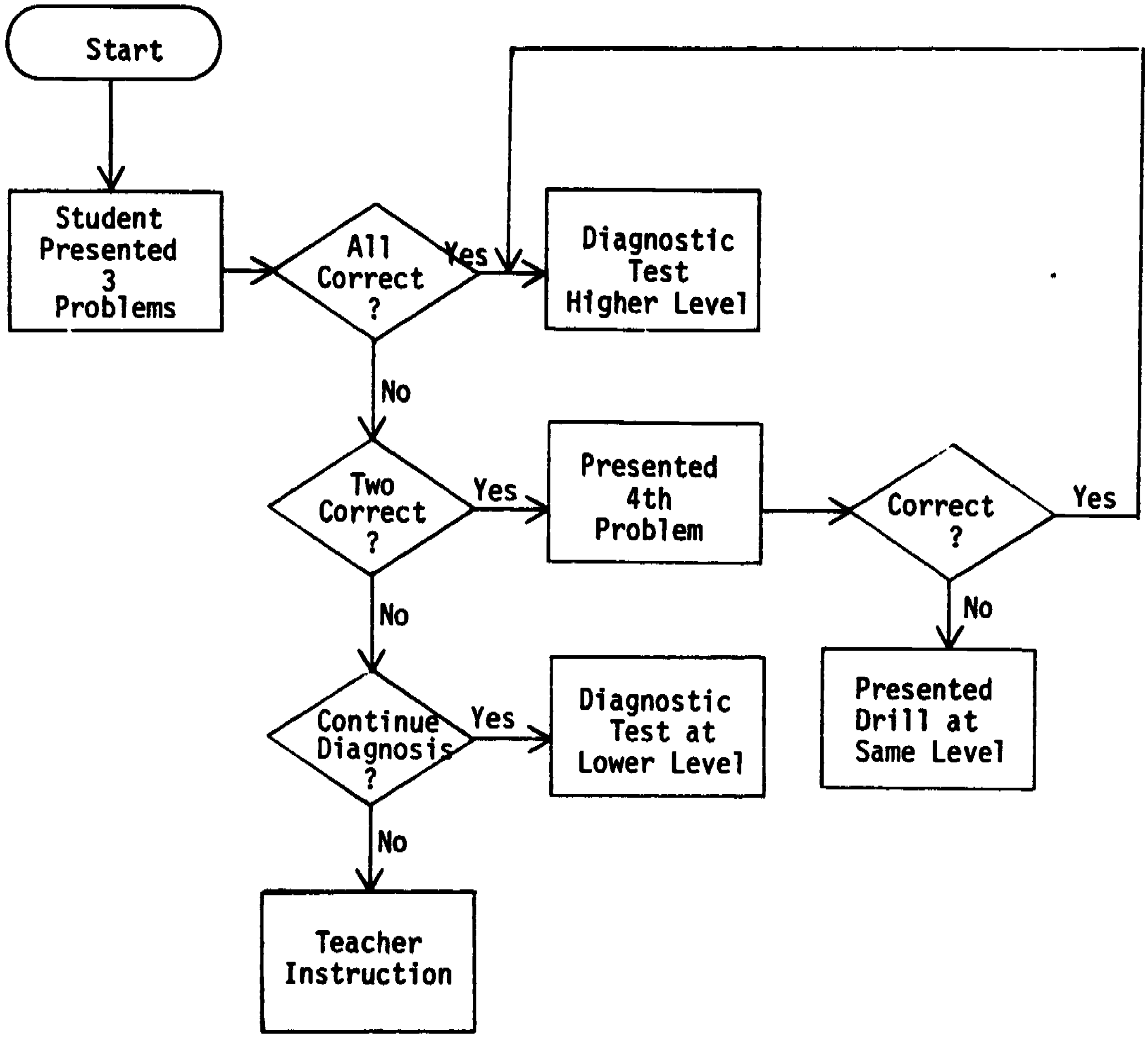
OPERATION WHOLE NUMBERS

Diagnostic Test Strategy



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For more detailed information on diagnostic sequences, refer to the program flowcharts included with each operation.

Drills

In all sections, a sequence of drills is designed so that each drill provides practice in a computational skill based upon a specific mathematical concept. There are 25 drill levels in addition, 21 in subtraction, 19 in multiplication, and 34 in division. The first 19 drills in division are 1-place divisors; Drills 20-34 have 2-place divisors. Most drills contain 10 problems although a few drills in multiplication contain only 5 problems.

Addition, Subtraction and Multiplication Drills

To pass a drill, the student must answer correctly nine out of ten (four out of five) problems. If he fails a drill on his first attempt with a score of five (two or less correct), he is branched for teacher instruction. If he fails the drill the first time with a score of six, seven, or eight correct (three in a five-problem drill), he is allowed to take an alternate form of the same drill. If he fails the drill on this second attempt, he is branched for teacher instruction. If the student misses the first three (two problems in a five-problem drill), he is immediately branched to his teacher for instruction before he attempts the drill again.

Computer-assisted instruction (CAI) is defined as the utilization of remote time-sharing computer terminals to assist the teacher in assuring student progress toward the attainment of specific learning objectives through the individualization of the instructional process.

Division Drills

All division drills contain ten problems. To pass a drill, the student must answer nine out of ten *or* the first five problems correctly. If he correctly answers the first five problems, he does not have to work all ten problems. Strategy on repeating a drill, branching for teacher instruction, and problem evaluation are the same as in the other three operations. In division drills, misplaced cursors are recorded by the computer but are not counted as wrong answers.

Review Tests

In a review test, problems from the preceding drill sequence are randomly presented. There are 22 review tests placed at plateau points in the developmental sequence of skills throughout the program. Most of these tests contain 20 problems; 2 in multiplication contain only 10 problems. The student is given only one attempt to answer a problem correctly. If he misses the problem, he is told, "Sorry! Your answer is wrong. Let's try the next problem."

To pass a review test, the student must answer 18 out of 20 (9 out of 10) problems correctly. If his score is 16 or 17 (8 out of 10 correct), he is given the opportunity to correct the problem(s) he missed. If he chooses to do so, the computer recalls those problems and evaluates a second time for a

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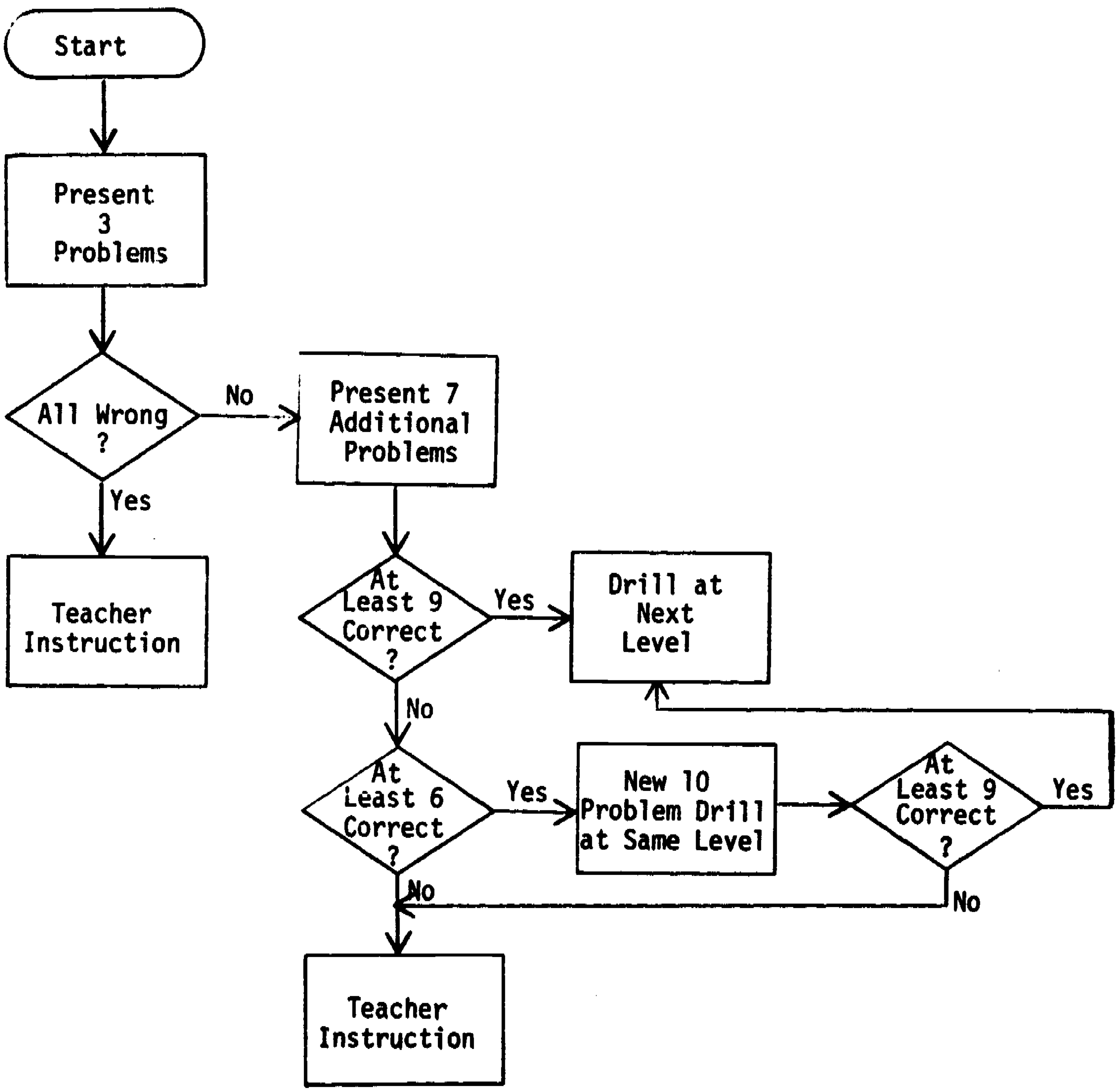
OPERATION WHOLE NUMBERS

Drill Strategy



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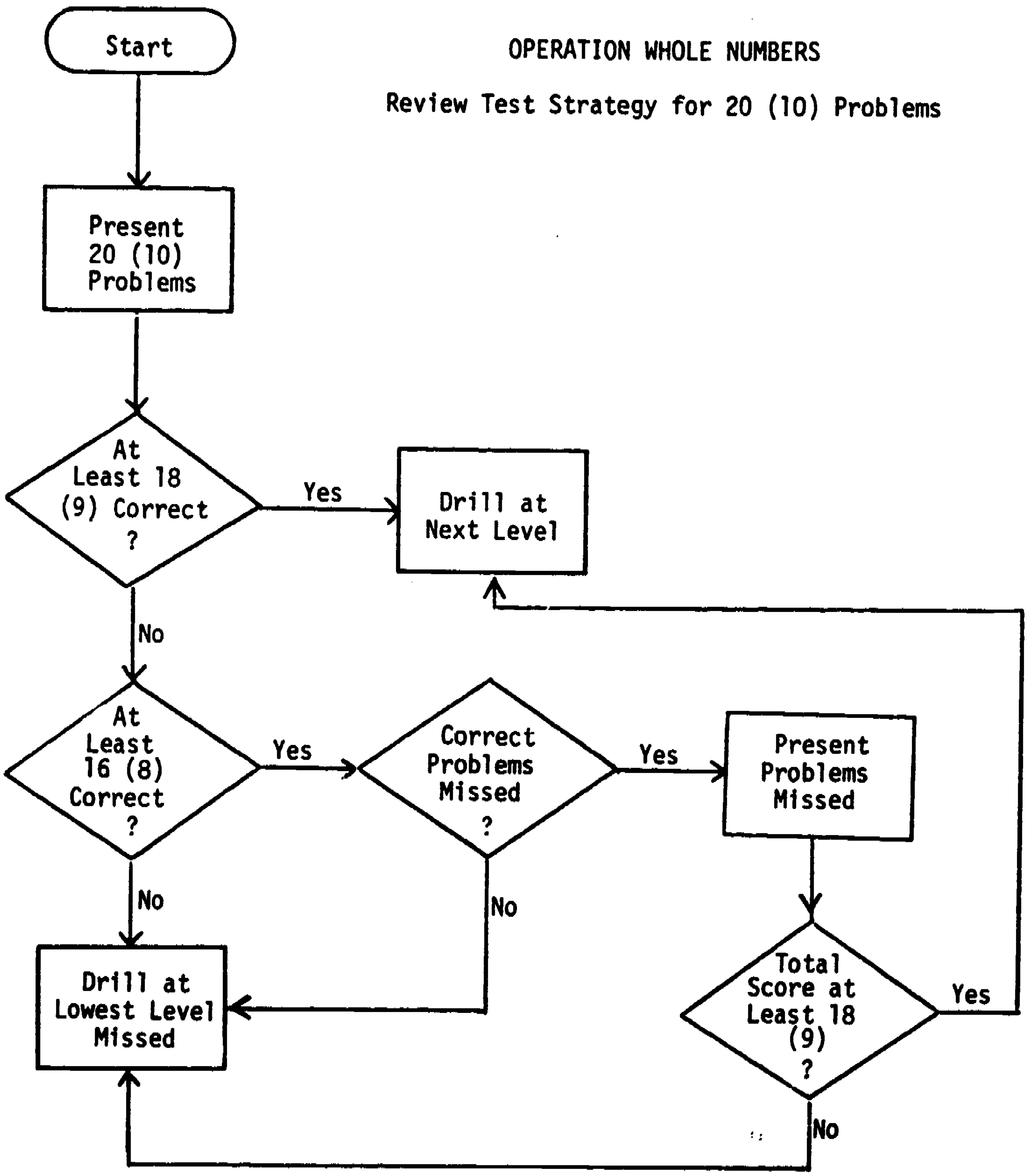
OPERATION WHOLE NUMBERS

Review Test Strategy for 20 (10) Problems



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passing score. If the student does not obtain a passing score after his second attempt at these three or four problems, or misses more than four problems on his first attempt at the review test, he is branched to the lowest drill level from which he missed a problem. He repeats the drill(s) and then the review test. If he fails the review test on his second attempt, he is branched for teacher instruction to the objective presented in the lowest drill level from which he missed a problem. When he returns for work on the terminal, he enters the drill sequence at that level.

In the multiplication and division review tests, problems are worked on paper, and only final answers are typed in. Misplaced cursors in division problems count as wrong answers.

Division Tutorial

Students whose performance in the division pretest indicates a need for instruction on rounding two-place numerals to the nearest ten and/or using rounded numerals to estimate quotients are branched to the appropriate tutorial segment. A student may enter from the pretest at one of several places: (1) Rounding, Objective 1; (2) Rounding, Objective 3; (3) Rounding, Objective 6; (4) Estimation I, which teaches the use of a rounded divisor to estimate a quotient in a problem for which estimation always works; or (5) Estimation II, which teaches that the estimated quotient is sometimes too large or too small to be part of the correct answer.

Students who begin the two-place divisors drill sequence at Level 20 will enter Rounding and Estimation I instruction after Review Test VII and will enter Estimation II after Review Test VIII.

Posttest

At the end of the program, the student is presented a posttest which measures attainment of the four terminal objectives. Twelve problems, three from each operation, are randomly presented.

Timing

Each of these activities is controlled by a predetermined time element. The time allotted to complete each problem is based on the difficulty of the problem.

If the student does not answer within the time allotted for a *drill* problem, he is "timed-out." If he "times-out" on his second attempt, he is given the correct answer to enter. Thus, the student can "time-out" twice on any given drill problem.

In a *review test,* each problem is not timed; but the student receives a total time allotment in which to complete the entire test. If he "times-out" on his first attempt, he is branched to the lowest drill level in the sequence. If he "times-out" on his second attempt in the review test, he is branched for teacher instruction.

Addition

Enabling Objectives

Level 1 Given an addition problem presented horizontally with two numbers whose sum is less than or equal to nine, the student constructs the sum.

Example: 3 + 4 =

There are 55 basic facts whose sums are less than or equal to nine. These facts are presented in two sections. The first section contains 27 facts while the second contains 28 basic facts.

Level 2 Given an addition problem presented horizontally or vertically, with three one-place numerals whose sum is less than or equal to nine, the student constructs the sum.

Examples: 3 + 3 + 2 =

$$\begin{array}{r} 1 \\ 6 \\ +\ 2 \\ \hline \end{array}$$

Level 3 Given an addition problem presented horizontally or vertically, with 2 multiples of 10 whose sum is less than or equal to 90, the student constructs the sum.

Examples: 40 + 20 =

$$\begin{array}{r} 50 \\ +\ 10 \\ \hline \end{array}$$

Level 4 Given an addition problem presented horizontally or vertically, with 2 multiples of 100 whose sum is less than or equal to 900, the student constructs the sum.

Examples: 600 + 100 =

$$\begin{array}{r} 700 \\ +\ 200 \\ \hline \end{array}$$

Level 5 Given an addition problem presented horizontally or vertically, with a multiple of ten and a one-place numeral, the student constructs the sum.

Examples: 30 + 8 =

$$\begin{array}{r} 10 \\ +\ \ 6 \\ \hline \end{array}$$

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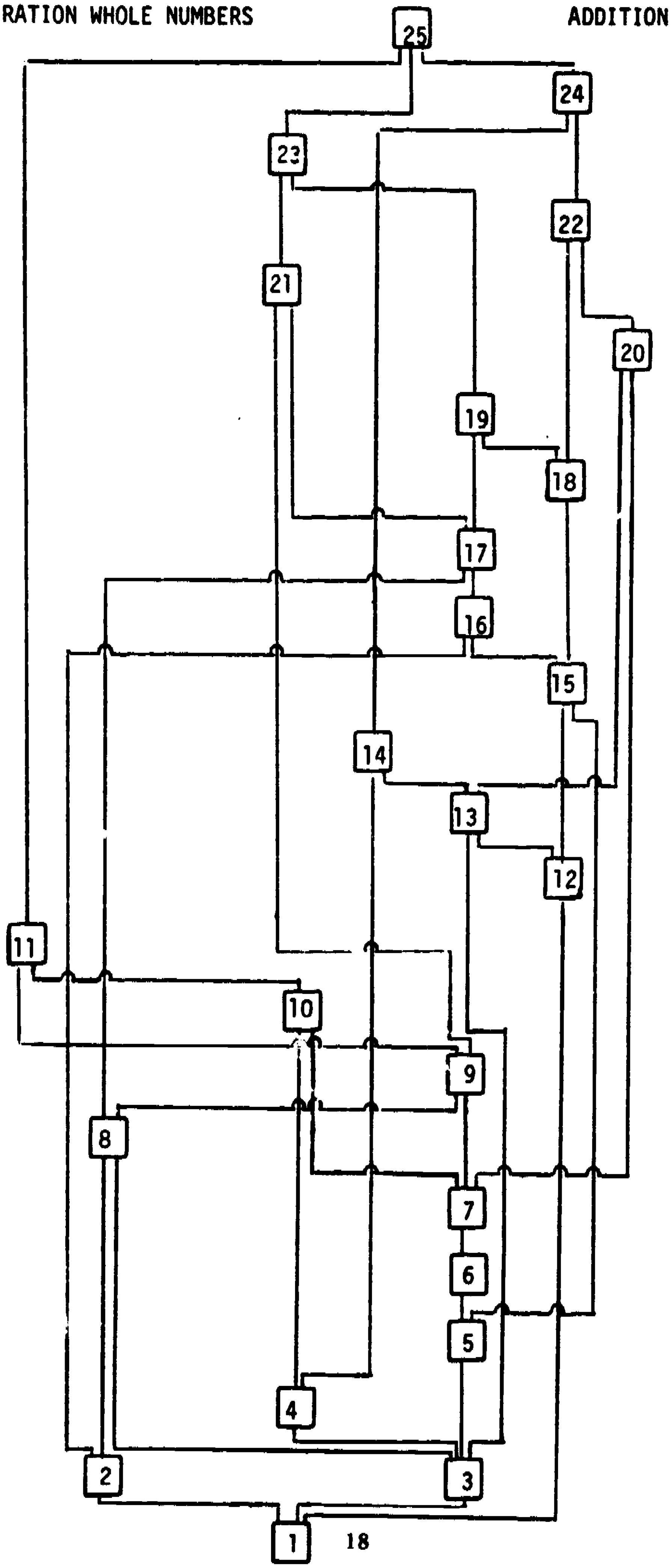
OPERATION WHOLE NUMBERS

ADDITION HIERARCHY



ERIC

Level 6 Given an addition problem presented horizontally or vertically, with a two-place numeral and a one-place numeral, the student constructs the sum; no regrouping is required.

Examples: 36 + 2 =

$$\begin{array}{r} 23 \\ \underline{+\ \ 4} \end{array}$$

Level 7 Given an addition problem with two 2-place numerals presented vertically, the student constructs the sum; no regrouping is required.

Example:

$$\begin{array}{r} 71 \\ \underline{+\ 16} \end{array}$$

Review Test I

This test contains 20 randomly presented problems from Drills 2–7; three problems are presented from Drills 2–5, and four each from Drills 6 and 7. All number combinations, regardless of place value, do not exceed 9.

Level 8 Given an addition problem presented vertically with 3 multiples of 10 whose sum is less than or equal to 90, the student constructs the sum.

Example:

$$\begin{array}{r} 40 \\ 20 \\ \underline{+\ 10} \end{array}$$

Level 9 Given an addition problem presented vertically with three 2-place numerals, the student constructs the sum; no regrouping is required.

Example:

$$\begin{array}{r} 11 \\ 22 \\ \underline{+\ 43} \end{array}$$

Level 10 Given an addition problem with two 3-place numerals presented vertically, the student constructs the sum; no regrouping is required.

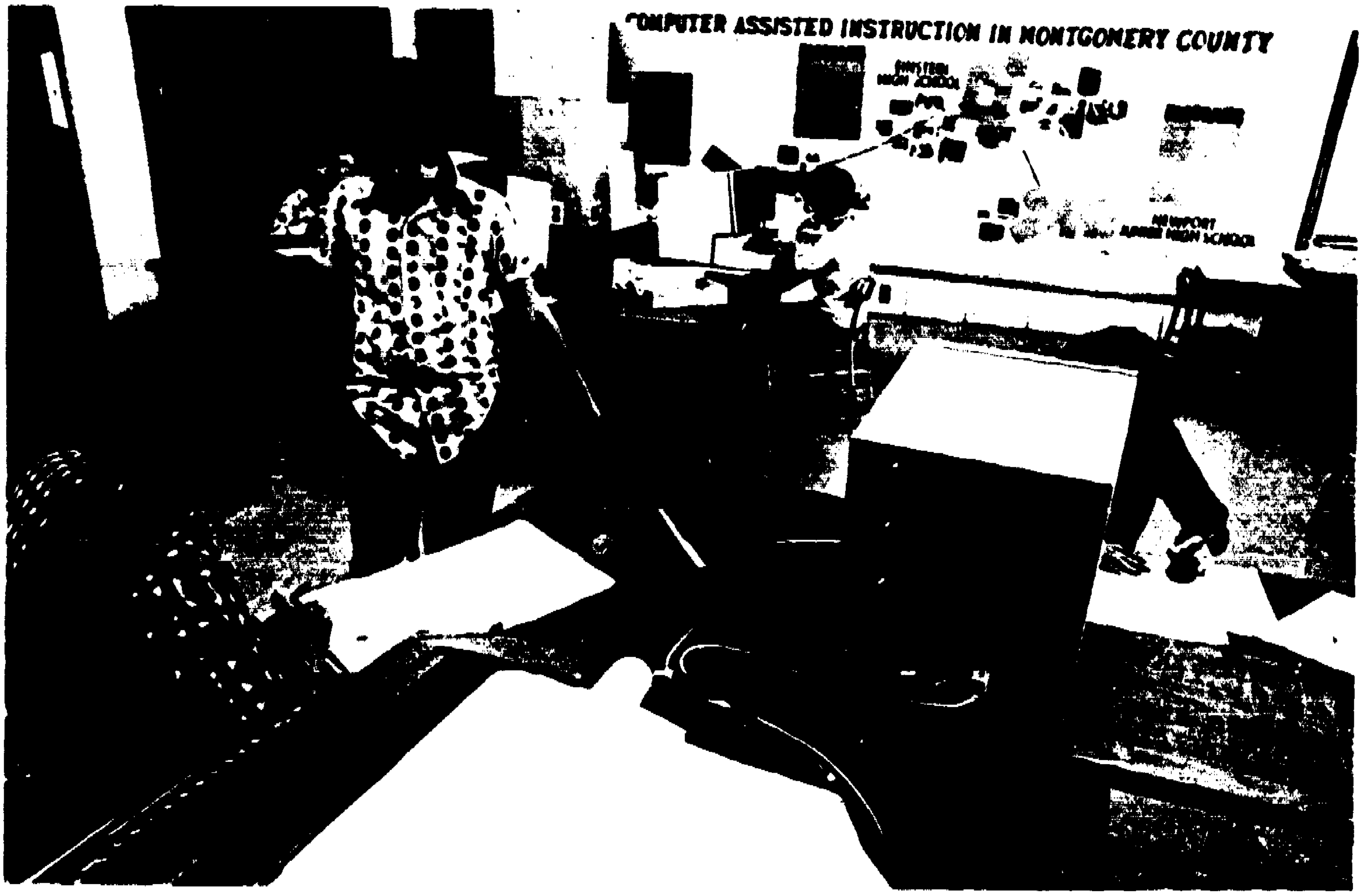
Example:

$$\begin{array}{r} 246 \\ \underline{+\ 523} \end{array}$$

Level 11 Given an addition problem presented vertically with three 3-place numerals, the student constructs the sum; no regrouping is required.

Example:

$$\begin{array}{r} 212 \\ 304 \\ \underline{+\ 131} \end{array}$$



The computer serves as a precise judge of each individual approach, whatever the level of sophistication.

Review Test II

This test contains 20 randomly presented problems from Drills 8–11, five problems from each drill. All number combinations, regardless of place value, do not exceed 9.

Level 12 Given an addition problem presented horizontally, with 2 numbers whose sum is greater than 9 but less than or equal to 18, the student constructs the sum.

Example: 8 + 7 =

There are 45 basic facts whose sums are greater than 9 but less than 18. These facts are presented in two sections: one containing 23 facts, the second containing 22 basic facts.

Level 13 Given an addition problem presented horizontally or vertically, with 2 multiples of 10 whose sum is less than or equal to 180, the student constructs the sum.

Examples: 90 + 20 =

$$\begin{array}{r} 80 \\ +\ 60 \\ \hline \end{array}$$

Level 14 Given an addition problem presented horizontally or vertically, with 2 multiples of 100 whose sum is less than or equal to 1800, the student constructs the sum.

Examples: 900 + 900 =

$$\begin{array}{r} 700 \\ +\ 600 \\ \hline \end{array}$$

Level 15 Given an addition problem presented horizontally or vertically, with a two-place and a one-place numeral, the student constructs the sum; regrouping from ones to tens is required.

Examples: $34 + 7 =$ $\begin{array}{r} 29 \\ +\ 6 \\ \hline \end{array}$

Level 16 Given an addition problem presented horizontally or vertically, with three 1-place numerals whose sum is greater than or equal to ten, the student constructs the sum.

Examples: $9 + 9 + 9 =$ $\begin{array}{r} 5 \\ 6 \\ +\ 4 \\ \hline \end{array}$

Level 17 Given an addition problem presented vertically with three multiples of ten, the student constructs the sum; regrouping from tens to hundreds is required.

Example: $\begin{array}{r} 30 \\ 40 \\ +\ 70 \\ \hline \end{array}$

Review Test III

This test contains 20 randomly presented problems from Drills 13–17, four problems from each drill.

Level 18 Given an addition problem with two 2-place numerals presented vertically, the student constructs the sum; regrouping from ones to tens is required.

Example: $\begin{array}{r} 18 \\ +\ 49 \\ \hline \end{array}$

Level 19 Given an addition problem with three 2-place numerals presented vertically, the student constructs the sum; regrouping from ones to tens is required.

Example: $\begin{array}{r} 26 \\ 25 \\ +\ 39 \\ \hline \end{array}$

Level 20 Given an addition problem with two 2-place numerals presented vertically, the student constructs the sum; regrouping from tens to hundreds is required.

Example: $\begin{array}{r} 95 \\ +\ 34 \\ \hline \end{array}$

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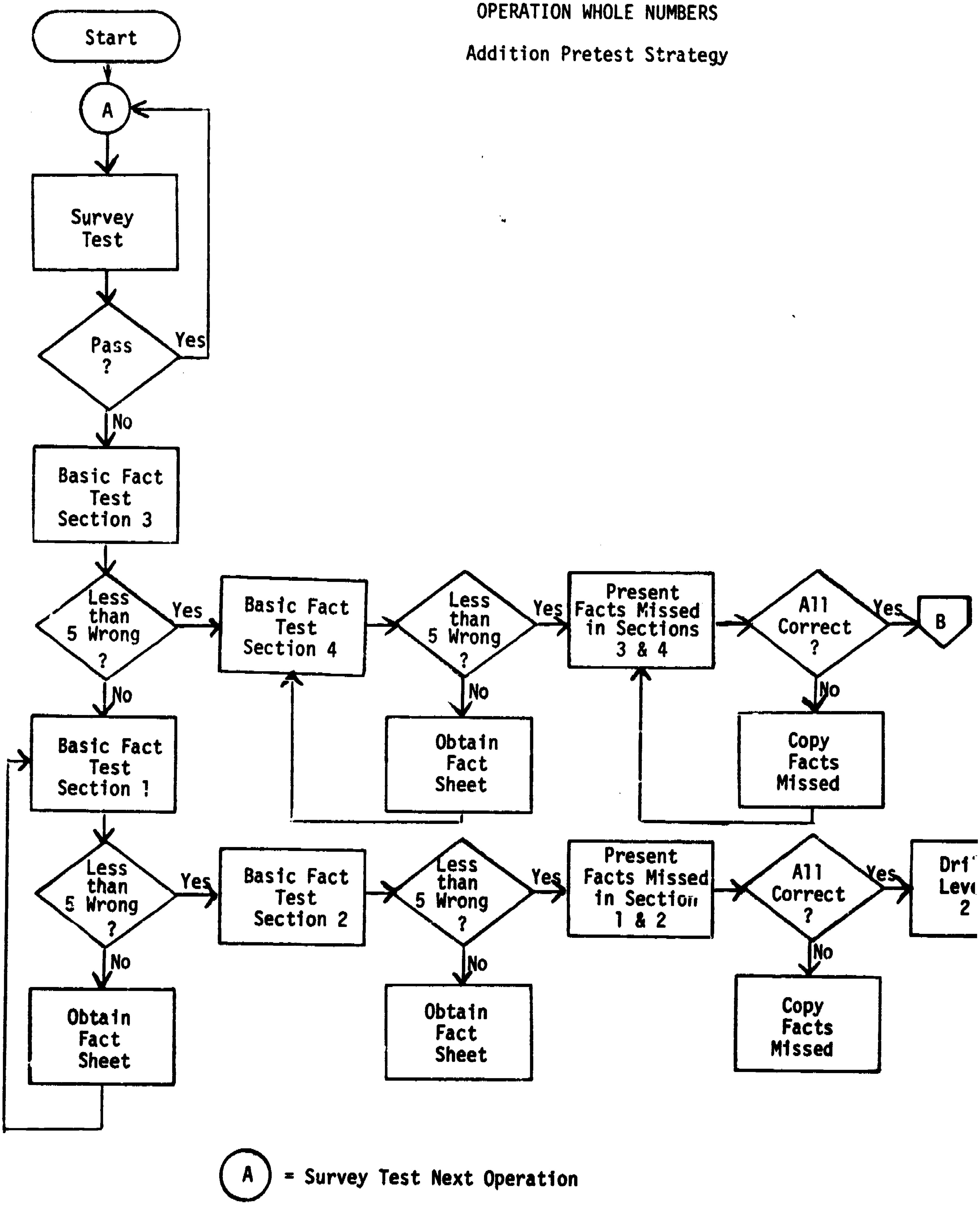
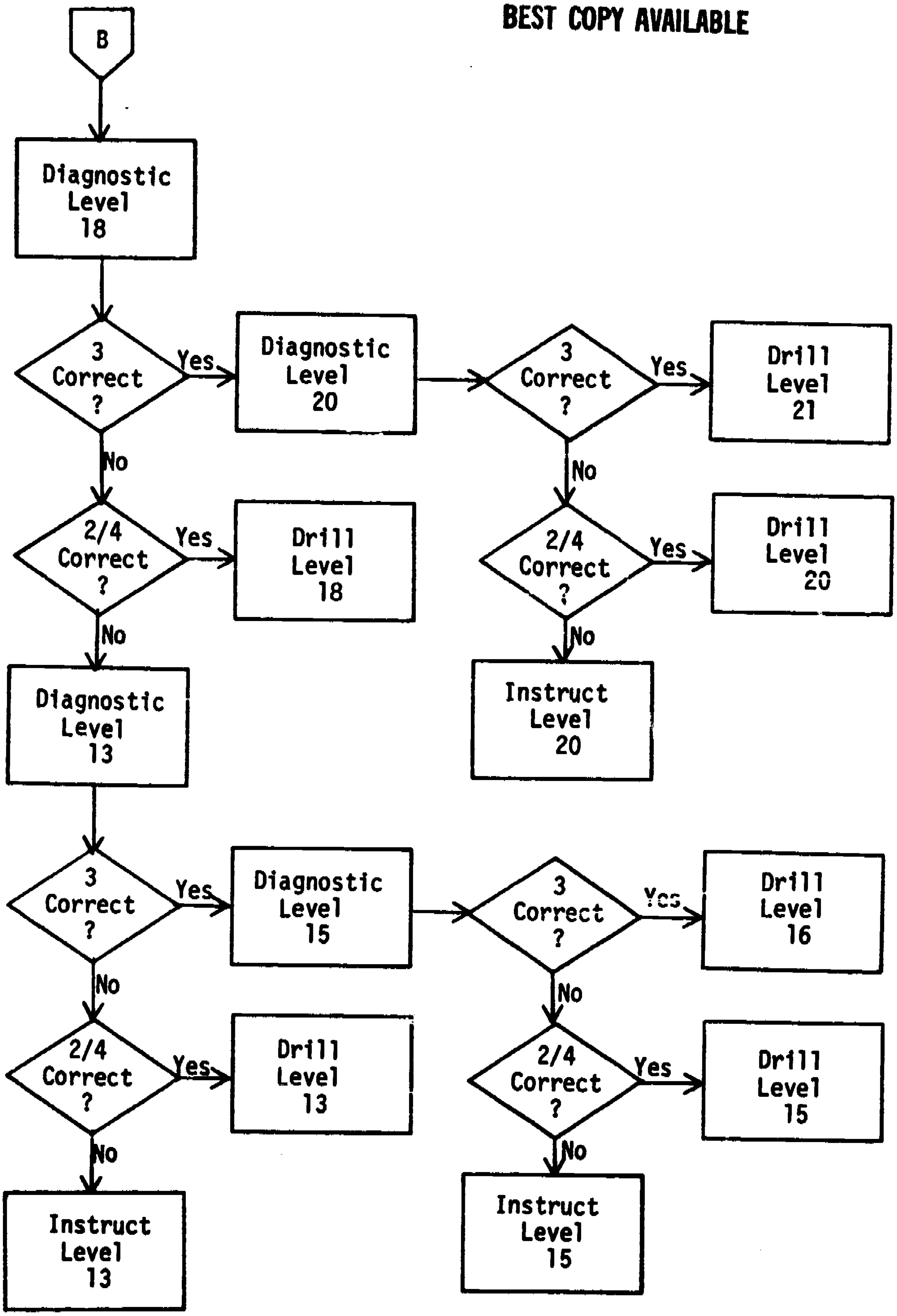
OPERATION WHOLE NUMBERS

Addition Pretest Strategy




B
Diagnostic Level 18
3 Correct ?
Yes
Diagnostic Level 20
3 Correct ?
Yes
Drill Level 21
No
2/4 Correct ?
Yes
Drill Level 18
No
2/4 Correct ?
Yes
Drill Level 20
No
Instruct Level 20
No
Diagnostic Level 13
3 Correct ?
Yes
Diagnostic Level 15
3 Correct ?
Yes
Drill Level 16
No
2/4 Correct ?
Yes
Drill Level 13
No
2/4 Correct ?
Yes
Drill Level 15
No
Instruct Level 13
No
Instruct Level 15

Level 21 Given an addition problem with three 2-place numerals presented vertically, the student constructs the sum; regrouping from tens to hundreds is required.

Example:
```
  22
  44
+ 71
```

Level 22 Given an addition problem with two 2-place numerals presented vertically, the student constructs the sum; regrouping from ones *and* tens places is required.

Example:
```
  96
+ 48
```

Level 23 Given an addition problem with three 2-place numerals presented vertically, the student constructs the sum; regrouping from ones *and* tens places is required.

Example:
```
  94
  25
+ 18
```

Review Test IV

This test contains 20 randomly presented problems from Drills 18–23: five problems from Drill 18 and 3 from each of Drills 19–23. Regrouping is required in all problems.

Level 24 Given an addition problem with two 3-place numerals presented vertically, the student constructs the sum; regrouping from ones, tens, and hundreds places is required.

Example:
```
  684
+ 937
```

Level 25 Given an addition problem with three 3-place numerals presented vertically, the student constructs the sum; regrouping from ones, tens, and hundreds places is required.

Example:
```
  986
  747
+ 568
```

Subtraction

Level 1 Given a subtraction problem presented horizontally or vertically, the student subtracts a number from a sum of nine or less.

Examples: 7 - 6 =
```
  8
- 4
```

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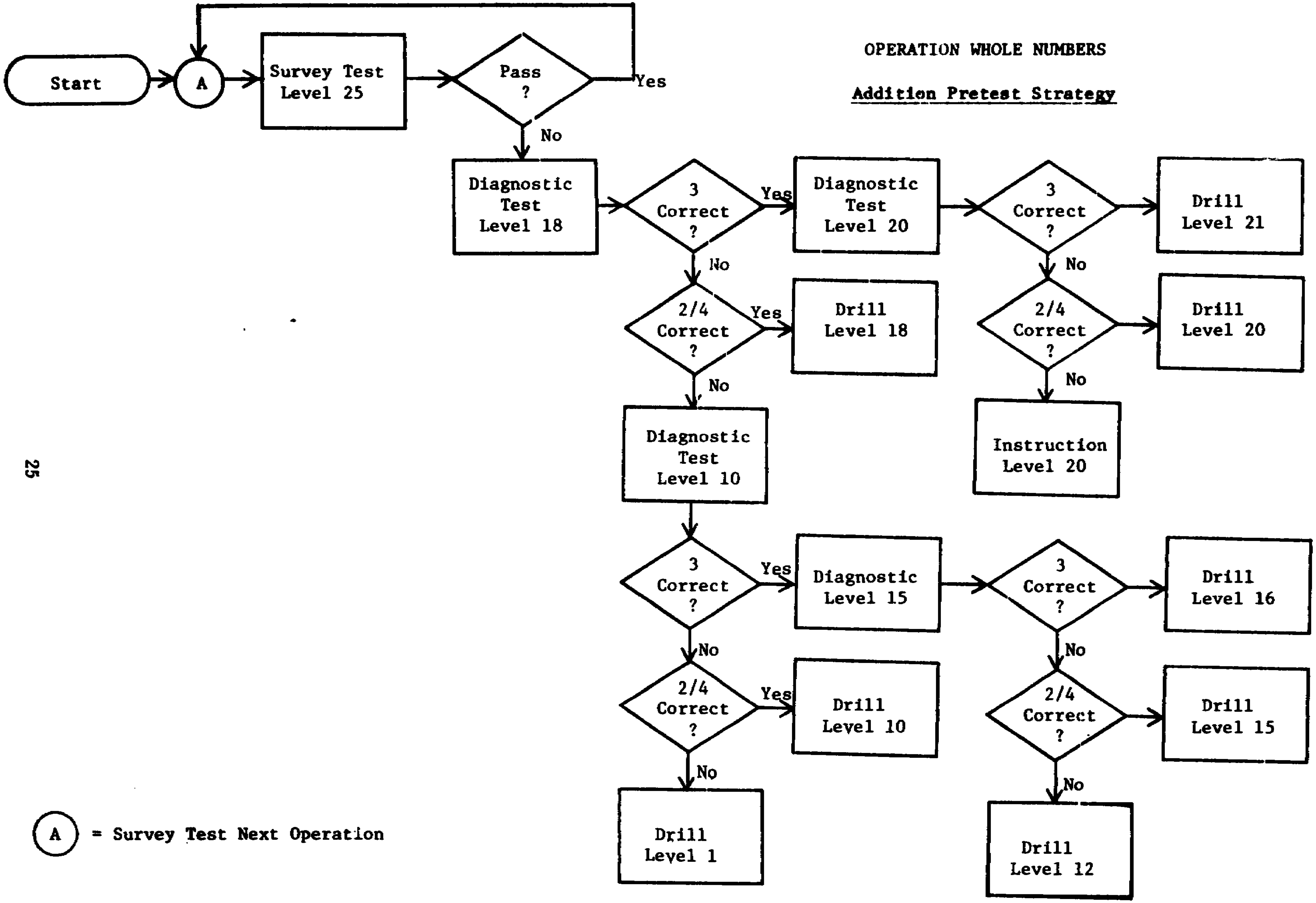
OPERATION WHOLE NUMBERS

Addition Pretest Strategy



(A) = Survey Test Next Operation

Level 2 Given a subtraction problem presented horizontally or vertically, the student subtracts a number from a sum of ten.

Examples: 10 - 6 =

$$\begin{array}{r} 10 \\ -\ 4 \\ \hline \end{array}$$

Level 3 Given a subtraction problem presented horizontally or vertically, the student subtracts multiples of 10 from a sum of 90 or less.

Examples: 40 - 20 =

$$\begin{array}{r} 70 \\ -\ 30 \\ \hline \end{array}$$

Level 4 Given a subtraction problem presented horizontally or vertically, the student subtracts multiples of 100 from a sum of 900 or less.

Examples: 700 - 500 =

$$\begin{array}{r} 600 \\ -\ 200 \\ \hline \end{array}$$

Level 5 Given a subtraction problem presented horizontally or vertically, the student subtracts a one-place numeral from a two-place numeral; regrouping is not required.

Examples: 76 - 2 =

$$\begin{array}{r} 65 \\ -\ 4 \\ \hline \end{array}$$

Level 6 Given a subtraction problem presented vertically, the student subtracts a two-place numeral from another two-place numeral; regrouping is not required.

Example:

$$\begin{array}{r} 86 \\ -\ 53 \\ \hline \end{array}$$

Level 7 Given a subtraction problem presented vertically, the student subtracts a three-place numeral from a three-place numeral; regrouping is not required.

Example:

$$\begin{array}{r} 789 \\ -\ 456 \\ \hline \end{array}$$

<u>**Review Test I**</u>

This test contains 20 randomly presented problems from Drills 1–7: two problems from Drills 1–4 and 4 problems from each of the Drills 5–7.

Level 8 Given a subtraction problem presented horizontally or vertically, the student subtracts a number from a sum of 18 or less.

Examples: 14 - 8 =

$$\begin{array}{r} 18 \\ -\ 9 \\ \hline \end{array}$$

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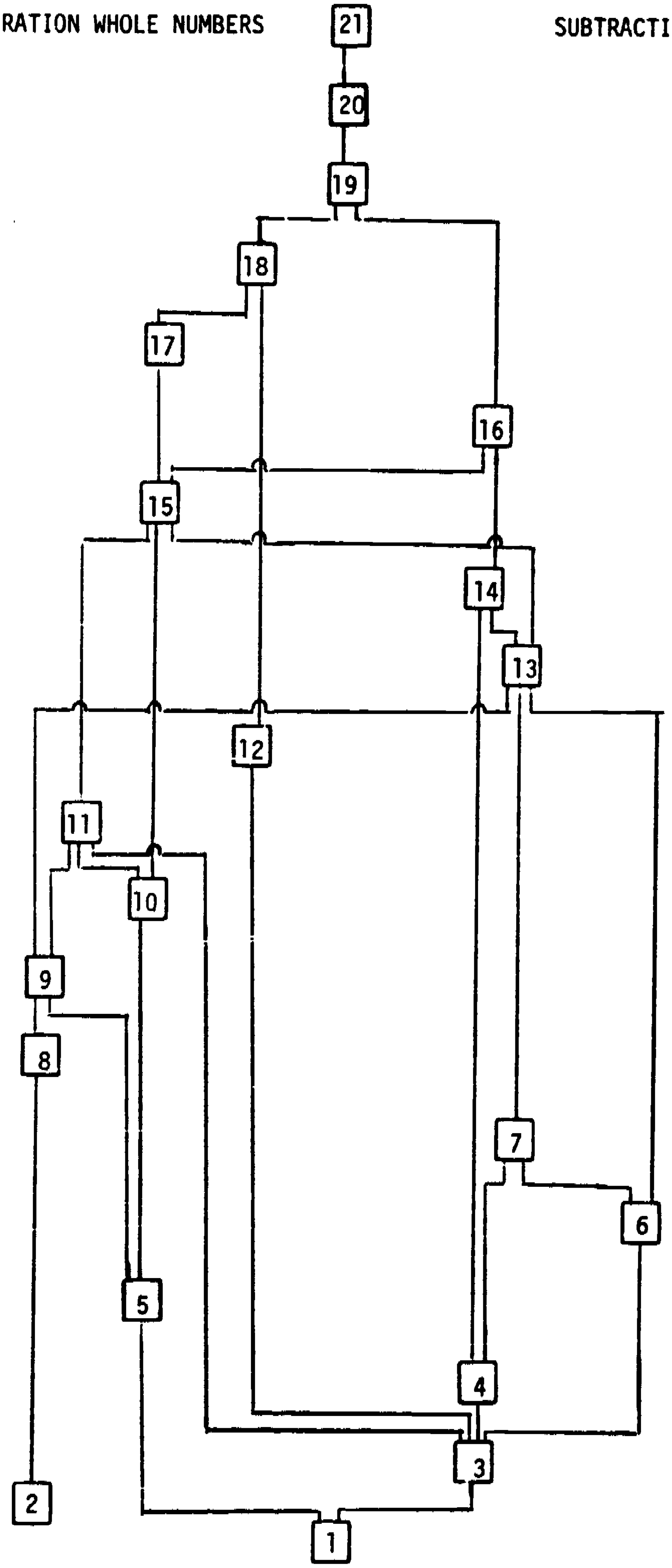
OPERATION WHOLE NUMBERS

SUBTRACTION HIERARCHY



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Level 9 — Given a subtraction problem presented horizontally or vertically, the student subtracts a one-place numeral from a two-place numeral not a multiple of ten; regrouping from tens to ones is required.

Examples: 36 - 9 =

$$\begin{array}{r} 24 \\ -\ 7 \\ \hline \end{array}$$

Level 10 — Given a subtraction problem presented horizontally or vertically, the student subtracts a one-place numeral from a multiple of ten; regrouping from tens to ones is required.

Examples: 20 - 6 =

$$\begin{array}{r} 30 \\ -\ 8 \\ \hline \end{array}$$

Level 11 — Given a subtraction problem presented vertically, the student subtracts a two-place numeral from a two-place numeral; regrouping from tens to ones is required.

Example:

$$\begin{array}{r} 38 \\ -\ 19 \\ \hline \end{array}$$

Level 12 — Given a subtraction problem presented vertically, the student subtracts a two-place numeral from a multiple of ten; regrouping from tens to ones is required.

Example:

$$\begin{array}{r} 40 \\ -\ 13 \\ \hline \end{array}$$

Pleasant View Elementary School, which is connected by underground coaxial cable to the computer at Einstein, houses six student terminals and a typewriter terminal in one room. Fourth, fifth, and sixth grade students use these terminals for diagnostic, drill, and tutorial programs.

ERIC

Review Test II

This test contains 20 randomly presented problems from Drills 8–12: three problems from Drill 8, 5 problems from Drill 9, and 4 from each of the Drills 10–12.

Level 13 Given a subtraction problem presented vertically, the student subtracts a two-place numeral from a three-place numeral; regrouping from hundreds to tens is required.

Example: $$\begin{array}{r} 367 \\ -\ \ 94 \\ \hline \end{array}$$

Level 14 Given a subtraction problem presented vertically, the student subtracts a three-place numeral from a three-place numeral; regrouping from hundreds to tens is required.

Example: $$\begin{array}{r} 725 \\ -\ 591 \\ \hline \end{array}$$

Level 15 Given a subtraction problem presented vertically, the student subtracts a two-place numeral from a three-place numeral; regrouping from hundreds to tens and from tens to ones is required. No zeros appear in the given problem.

Examples: $$\begin{array}{r} 324 \\ -\ \ 96 \\ \hline \end{array} \qquad \begin{array}{r} 214 \\ -\ \ 96 \\ \hline \end{array}$$

Level 16 Given a subtraction problem presented vertically, the student subtracts a three-place numeral from a three-place numeral; regrouping from hundreds to tens and from tens to ones is required. No zeros appear in the tens place.

Examples: $$\begin{array}{r} 846 \\ -\ 357 \\ \hline \end{array} \qquad \begin{array}{r} 716 \\ -\ 357 \\ \hline \end{array}$$

Review Test III

This test contains 20 randomly presented problems from Drills 13 through 16: four problems from each of the Drills 13 and 14, and 6 problems from each of the Drills 15 and 16.

Level 17 Given a subtraction problem presented vertically, the student subtracts a two-place numeral from a three-place numeral having a zero in tens place; regrouping from hundreds to tens and from tens to ones is required.

Examples: $$\begin{array}{r} 603 \\ -\ \ 46 \\ \hline \end{array} \qquad \begin{array}{r} 904 \\ -\ \ 16 \\ \hline \end{array}$$

Level 18 Given a subtraction problem presented vertically, the student subtracts a two-place numeral from a multiple of 100; regrouping from hundreds to tens and from tens to ones is required.

Example: $$\begin{array}{r} 500 \\ -\ \ 56 \\ \hline \end{array}$$

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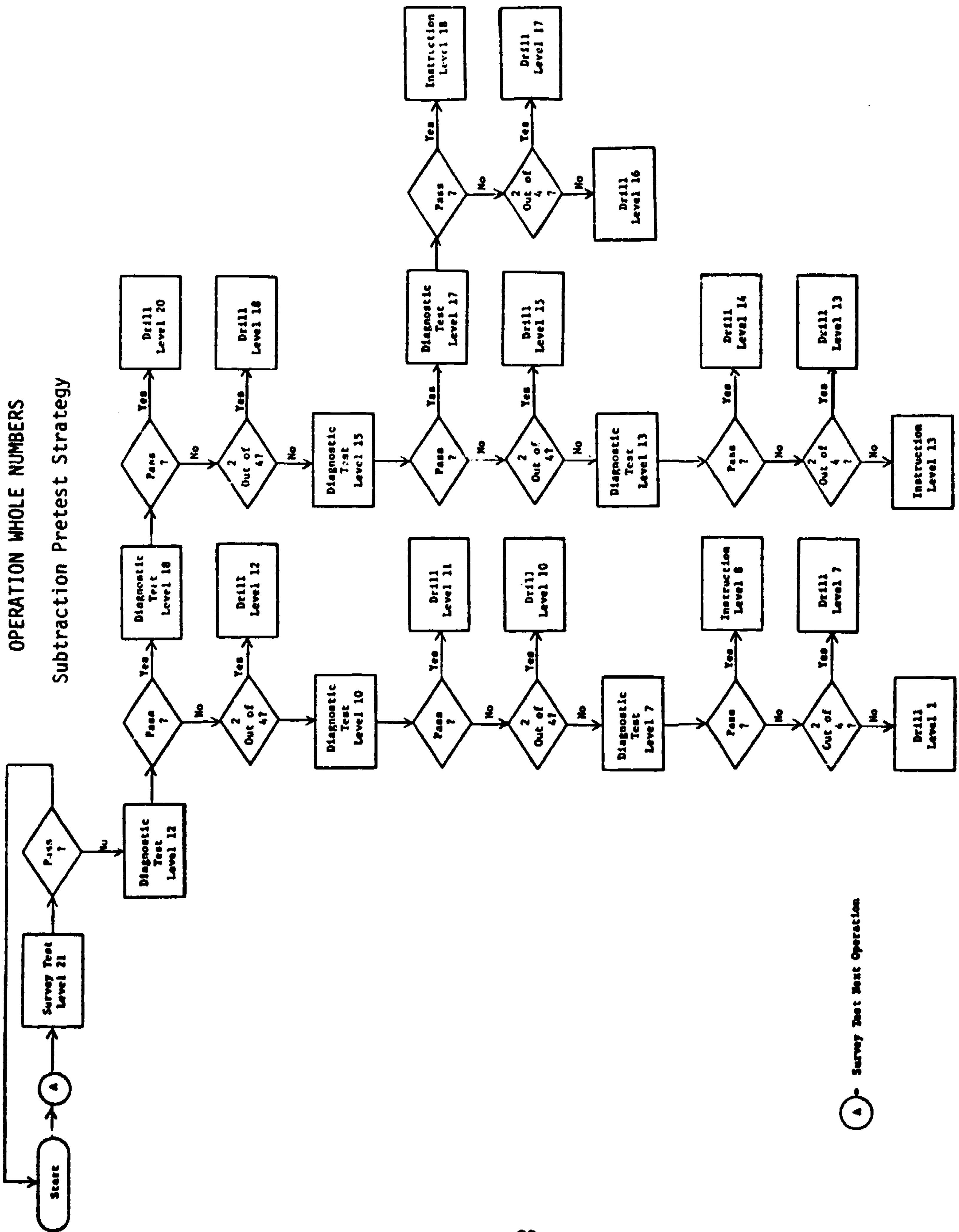
OPERATION WHOLE NUMBERS

Subtraction Pretest Strategy



Level 19 Given a subtraction problem presented vertically, the student subtracts a three-place numeral from a four-place numeral less than 2,000; regrouping in hundreds, tens, and ones is required.

Examples:

```
  1,432        1,000
-   654      -   567
```

Level 20 Given a subtraction problem presented vertically, the student subtracts a three-place numeral from a four-place numeral greater than 1,999; regrouping in hundreds, tens, and ones is required.

Examples:

```
  7,634        3,000
-   757      -   379
```

Review Test IV

This test contains 20 randomly presented problems from Drills 17–20: four problems from each of Drills 17 and 18, and 6 problems from each of the Drills 19 and 20.

Level 21 Given a subtraction problem presented vertically, the student subtracts a four-place numeral from a four-place numeral; regrouping in hundreds, tens, and ones is required.

Examples:

```
  9,284        9,000
- 7,995      - 7,995
```

Multiplication

Level 1 Given a multiplication problem presented horizontally, the student constructs the product when one factor is a number from zero to five and the other factor is a number from zero to nine.

Example: 4 X 5 =

There are 60 basic facts which match the above objective. The facts are presented in two sections, each containing 30 items.

Level 2 Given a multiplication problem presented horizontally or vertically, the student constructs the product when one factor is a numeral from zero to five and the other factor is a multiple of ten.

Examples: 4 X 50 =

50 X 4 =

```
   50
X   4
```

Level 3 Given a multiplication problem presented horizontally or vertically, the student constructs the product when one factor is a numeral from zero to five and the other factor is a multiple of one hundred.

Examples: 4 X 500 =

200 X 3 =

```
  200
X   3
```

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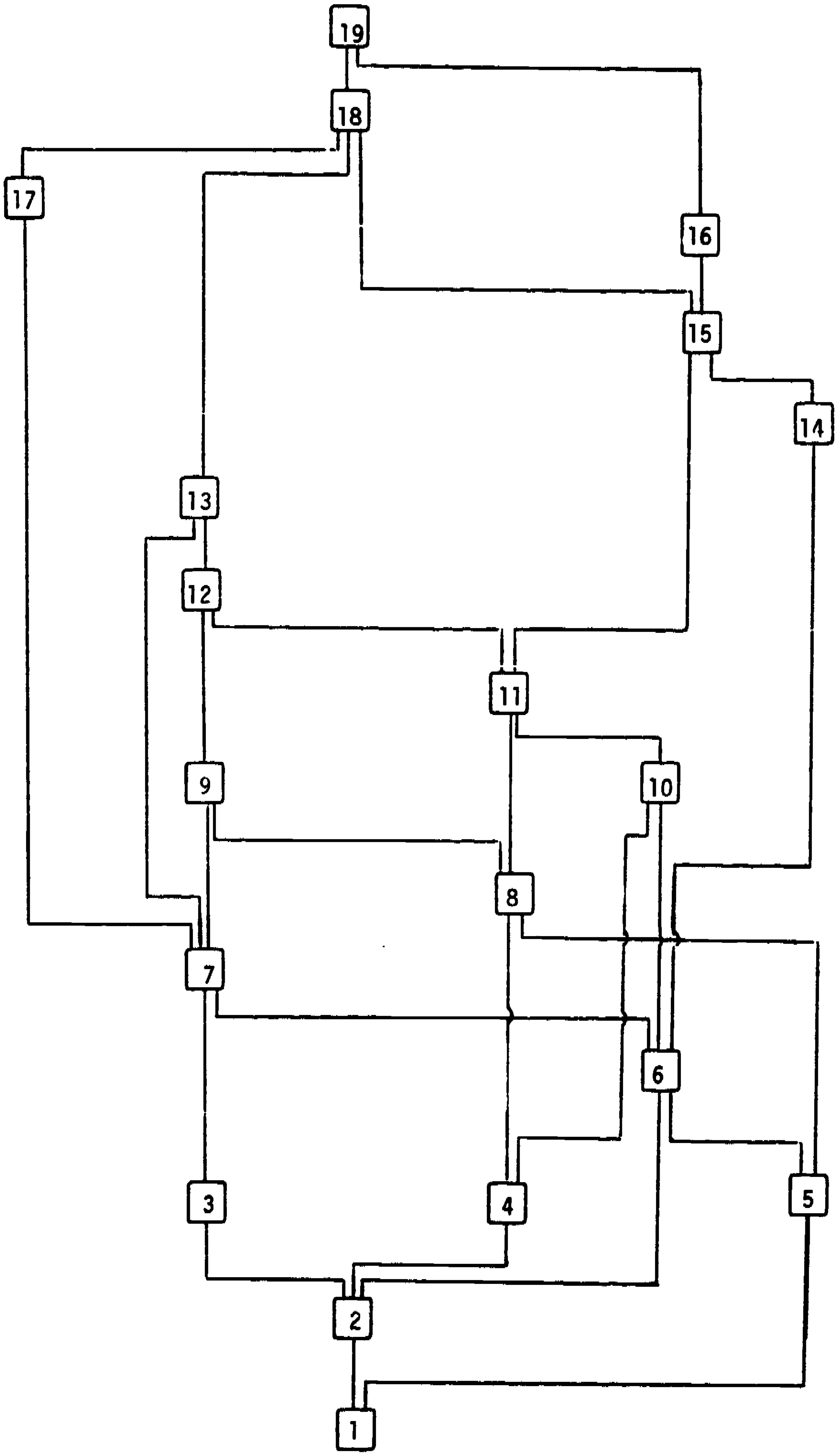
OPERATION WHOLE NUMBERS   MULTIPLICATION HIERARCHY



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Level 4 Given a multiplication problem presented vertically, the student constructs the product without regrouping when one factor is a two-place numeral and the other factor is a one-place numeral from one to five.

Examples: 12 × 4 11 × 5

$$\begin{array}{r} 12 \\ \underline{\times\ 4} \end{array} \qquad \begin{array}{r} 11 \\ \underline{\times\ 5} \end{array}$$

Review Test I

This test contains 10 randomly presented problems from Drills 2–4: three problems each from Drills 2 and 3, four from Drill 4.

Level 5 Given a multiplication problem presented horizontally, the student constructs the product when one factor is a number from six to nine and the other factor is a number from zero to nine.

Example: 6 X 7 =

The 40 basic facts which measure the attainment of this objective are presented in two sections. Each section contains 20 facts.

Level 6 Given a multiplication problem presented horizontally or vertically, the student constructs the product when the one factor is a number from six to nine and the other factor is a multiple of ten.

Examples: 6 X 70 =
70 X 6 =

$$\begin{array}{r} 90 \\ \underline{\times\ 8} \end{array}$$

Level 7 Given a multiplication problem presented horizontally or vertically, the student constructs the product when one factor is a number from six to nine and other other factor is a multiple of one hundred.

Examples: 6 X 700 =
700 X 6 =

$$\begin{array}{r} 700 \\ \underline{\times\ \ 6} \end{array}$$

Review Test II

This test contains 10 randomly presented problems from Drills 6 and 7. There are five problems from each drill.

Level 8 Given a multiplication problem presented vertically, the student constructs the product, regrouping from ones to tens, when one factor is a two-place numeral and the other factor is a one-place numeral.

Examples:

$$\begin{array}{r} 13 \\ \underline{\times\ 5} \end{array} \qquad \begin{array}{r} 24 \\ \underline{\times\ 4} \end{array}$$

Level 9 Given a multiplication problem presented vertically, the student constructs the product, regrouping from ones to tens, when one factor is a three-place numeral and the other factor is a one-place numeral.

Examples:

$$\begin{array}{r} 118 \\ \underline{\times\ \ 2} \end{array} \qquad \begin{array}{r} 123 \\ \underline{\times\ \ 4} \end{array}$$

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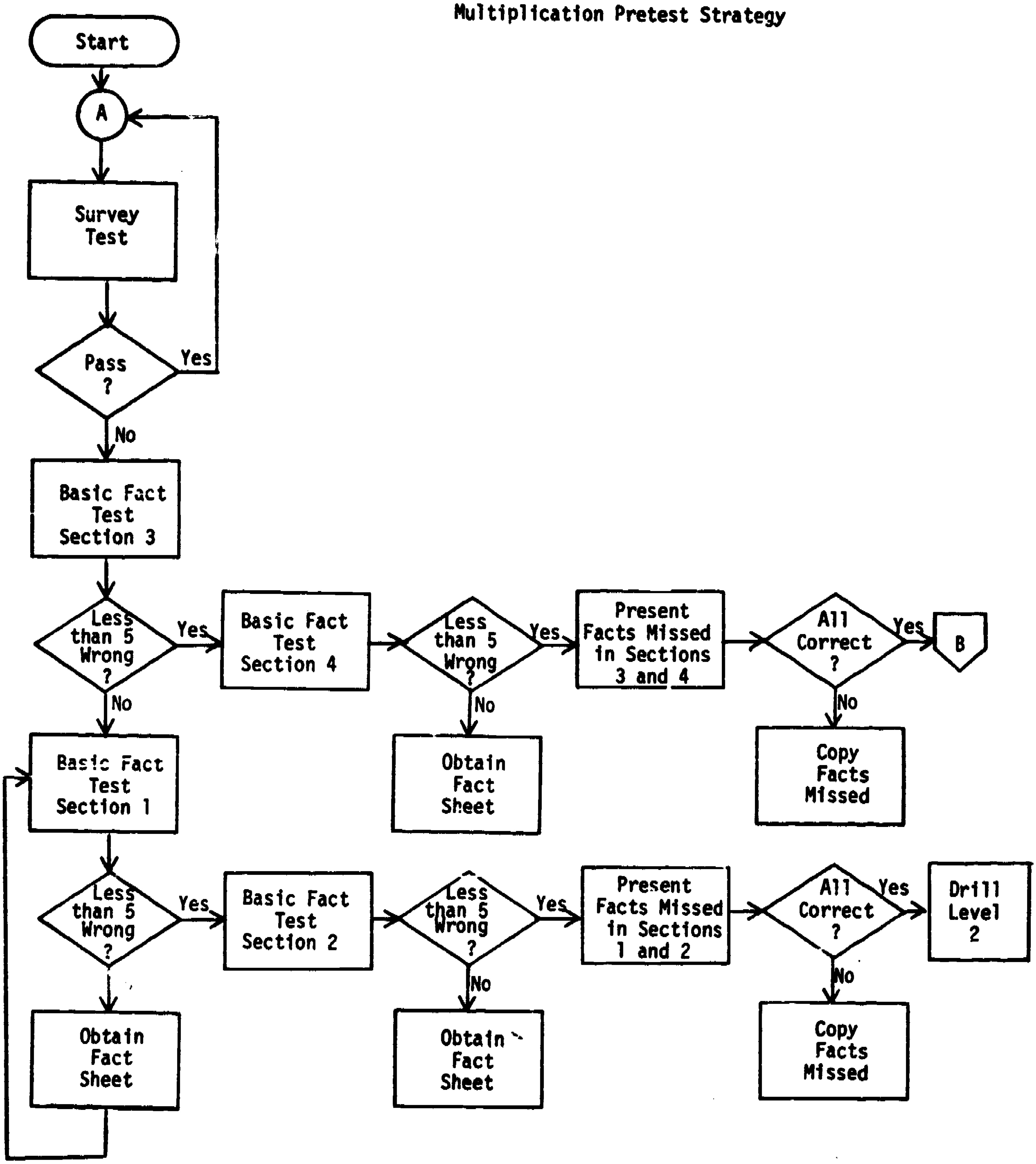
OPERATION WHOLE NUMBERS

Multiplication Pretest Strategy



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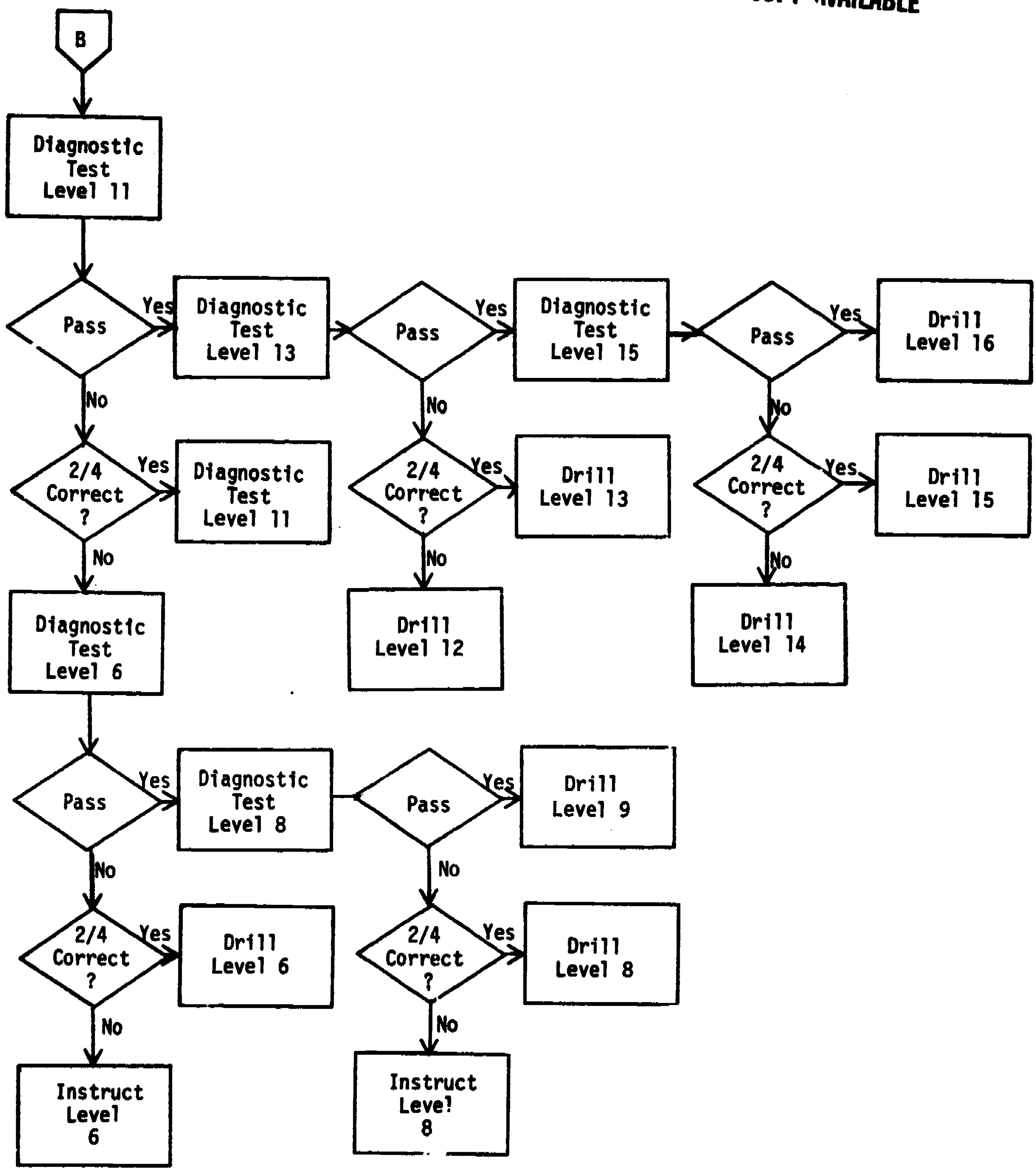

Level 10 Given a multiplication problem presented vertically, the student constructs the product, regrouping in tens, when one factor is a two-place numeral and the other factor is a one-place numeral.

Examples: $\begin{array}{r} 72 \\ \times\ 4 \\ \hline \end{array}$ $\begin{array}{r} 41 \\ \times\ 5 \\ \hline \end{array}$

Review Test III

This test contains ten randomly presented problems from Drills 8–10: four problems from Drill 8 and three problems from each of Drills 9 and 10.

Level 11 Given a multiplication problem presented vertically, the student constructs the product, regrouping in ones and tens, when one factor is a two-place numeral and the other factor is a one-place numeral.

Examples: $\begin{array}{r} 37 \\ \times\ 8 \\ \hline \end{array}$ $\begin{array}{r} 49 \\ \times\ 5 \\ \hline \end{array}$

Level 12 Given a multiplication problem presented vertically, the student constructs the product, regrouping in ones and tens, when one factor is a three-place numeral and the other factor is a one-place numeral.

Examples: $\begin{array}{r} 154 \\ \times\ \ \ 5 \\ \hline \end{array}$ $\begin{array}{r} 167 \\ \times\ \ \ 2 \\ \hline \end{array}$

Level 13 Given a multiplication problem presented vertically, the student constructs the product, regrouping in ones, tens, and hundreds, when one factor is a three-place numeral and the other factor is a one-place numeral.

Examples: $\begin{array}{r} 293 \\ \times\ \ \ 6 \\ \hline \end{array}$ $\begin{array}{r} 425 \\ \times\ \ \ 7 \\ \hline \end{array}$

Review Test IV

This test contains ten randomly presented problems from Drills 11–13: three problems from each of Drills 11 and 12 and four problems from Drill 13.

Level 14 Given a multiplication problem presented horizontally or vertically, the student constructs the product when both factors are multiples of ten.

Examples: $20 \times 30 =$ $\begin{array}{r} 40 \\ \times\ 60 \\ \hline \end{array}$

Level 15 Given a multiplication problem presented vertically, the student constructs the product, regrouping from tens to hundreds, when one factor is a two-place numeral and the other factor is a multiple of ten.

Examples: $\begin{array}{r} 29 \\ \times\ 30 \\ \hline \end{array}$ $\begin{array}{r} 73 \\ \times\ 80 \\ \hline \end{array}$

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Level 16 Given a multiplication problem presented vertically, the student constructs the product, regrouping when each factor is a two-place numeral.

Examples: $\begin{array}{r} 29 \\ \times\ 64 \\ \hline \end{array}$ $\begin{array}{r} 38 \\ \times\ 45 \\ \hline \end{array}$

Level 17 Given a multiplication problem presented horizontally or vertically, the student constructs the product when one factor is a multiple of 100 and the other factor is a multiple of 10.

Examples: $\begin{array}{r} 700 \\ \times\ 30 \\ \hline \end{array}$ 40 X 600 =
800 X 50 =

Level 18 Given a multiplication problem presented vertically, the student constructs the product, regrouping when one factor is a three-place numeral and the other factor is a multiple of ten.

Examples: $\begin{array}{r} 725 \\ \times\ 30 \\ \hline \end{array}$ $\begin{array}{r} 612 \\ \times\ 80 \\ \hline \end{array}$

Review Test V

This test contains 20 randomly presented problems from drills 14–18: four problems from each of the five drills.

Level 19 Given a multiplication problem presented vertically, the student constructs the product, regrouping when one factor is a three-place numeral and the other factor is a two-place numeral.

Examples: $\begin{array}{r} 763 \\ \times\ 25 \\ \hline \end{array}$ $\begin{array}{r} 894 \\ \times\ 36 \\ \hline \end{array}$

Division

Level 1 Given a divisor from one to five and a dividend which is a multiple of the divisor, the student constructs the one-place quotient.

Examples: 15 ÷ 5 = $4\overline{)16}$

Level 2 Given a divisor from one to five and a dividend which is *not* a multiple of the divisor, the student constructs the one-place quotient and the remainder.

Examples: 16 ÷ 5 = $4\overline{)18}$

Level 3 Given a divisor from six to nine and a dividend which is a multiple of the divisor, the student constructs the one-place quotient.

Examples: 18 ÷ 6 = $7\overline{)28}$

Level 4 Given a divisor from six to nine and a dividend which is *not* a multiple of the divisor, the student constructs the one-place quotient and the remainder.

Examples: $27 \div 6 =$ $8\overline{)25}$

Review Test I

This test contains 20 randomly presented problems, 5 from each of Drills 1–4.

Level 5 Given a one-place divisor and a dividend which is a multiple of ten and a multiple of the divisor, the student constructs the quotient, which is a multiple of ten.

Examples: $50 \div 5 =$ $3\overline{)60}$

Given a one-place divisor and a dividend which is *not* a multiple of ten and *not* a multiple of the divisor, the student constructs the quotient, which is a multiple of ten, and the remainder.

Example: $6\overline{)65}$

Level 6 Given a one-place divisor and a dividend which is *not* a multiple of ten but is a multiple of the divisor, the student constructs the quotient.

Example: $2\overline{)48}$

Given a one-place divisor and a dividend which is *not* a multiple of ten and is *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $5\overline{)56}$

Level 7 Given a one-place divisor and a dividend which is a multiple of ten and a multiple of the divisor, the student constructs the quotient.

Example: $2\overline{)70}$

Given a one-place divisor and a dividend which is a multiple of ten but is *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $3\overline{)50}$

Level 8 Given a one-place divisor and a dividend which is *not* a multiple of ten but is a multiple of the divisor, the student constructs the quotient.

Example: $8\overline{)96}$

Given a one-place divisor and a dividend which is *not* a multiple of ten or a multiple of the divisor, the student constructs the quotient with the remainder.

Example: $3\overline{)72}$

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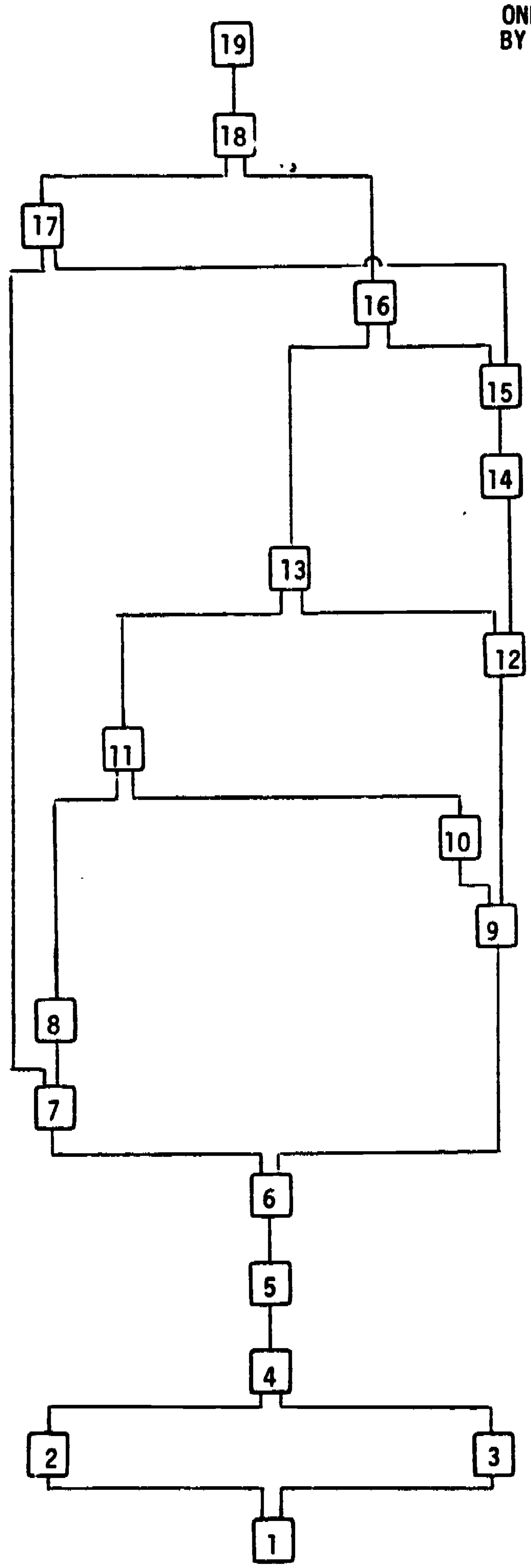
OPERATION WHOLE NUMBERS

DIVISION HIERARCHY
ONE-PLACE DIVISORS
BY DRILL LEVELS



Review Test II

This test contains 20 randomly presented problems, 5 from each of Drills 5–8.

Level 9 Given a one-place divisor and a dividend which is a multiple of 100 and a multiple of the divisor, the student constructs the quotient, which is a multiple of 10.

Example: $5\overline{)200}$

Given a one-place divisor and a dividend which is *not* a multiple of 100 and is *not* a multiple of the divisor, the student constructs the quotient, which is a multiple of 10, and the remainder.

Example: $5\overline{)403}$

Given a one-place divisor and a dividend which is *not* a multiple of 100 but is a multiple of the divisor, the student writes the quotient.

Example: $5\overline{)205}$

Given a one-place divisor and a dividend which is *not* a multiple of 100 and *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $5\overline{)408}$

Level 10 Given a one-place divisor and a dividend which is a multiple of ten and a multiple of the divisor, the student constructs the quotient, which is a multiple of ten.

Example: $8\overline{)240}$

Given a one-place divisor and a dividend which is *not* a multiple of ten but is a multiple of the divisor, the student constructs the quotient.

Example: $8\overline{)248}$

Given a one-place divisor and a dividend which is *not* a multiple of ten or a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $8\overline{)249}$

Given a one-place divisor and a dividend which is *not* a multiple of ten and *not* a multiple of the divisor, the student constructs the quotient, which is a multiple of ten and the remainder.

Example: $8\overline{)246}$

Level 11 Given a one-place divisor and a dividend which is a multiple of ten and a multiple of the divisor, the student constructs the quotient.

Example: $5\overline{)230}$

Given a one-place divisor and a dividend which is a multiple of ten but *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $4\overline{)230}$

Given a one-place divisor and a dividend which is *not* a multiple of ten but is a multiple of the divisor, the student constructs the quotient.

Example: $4\overline{)264}$

Given a one-place divisor and a dividend which is *not* a multiple of ten and *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $8\overline{)766}$

Review Test III

This test contains 20 randomly presented problems from Drills 9–11. There are six problems from Drill 9 and seven problems from each of Drills 10 and 11.

Level 12 Given a one-place divisor and a dividend which is a multiple of the divisor and a multiple of 100, the student constructs the quotient, which is a multiple of 100.

Example: $2\overline{)800}$

Given a one-place divisor and a dividend which is a multiple of the divisor, the student constructs the quotient.

Example: $2\overline{)802}$

Given a one-place divisor and a dividend which is *not* a multiple of the divisor, the student constructs the quotient, which is a multiple of 100, and the remainder.

Example: $3\overline{)602}$

Given a one-place divisor and a dividend which is *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $3\overline{)907}$

Level 13 Given a one-place divisor and a dividend which is a multiple of the divisor, the student constructs the quotient.

Example: $3\overline{)915}$

Given a one-place divisor and a dividend which is *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $3\overline{)917}$

Level 14 Given a one-place divisor and a dividend which is a multiple of ten and a multiple of the divisor, the student constructs the quotient, which is a multiple of ten.

Example: $2\overline{)820}$

Given a one-place divisor and a dividend which is *not* a multiple of the divisor, the student constructs the quotient, which is a multiple of ten, and the remainder.

Example: $2\overline{)821}$

Review Test IV

This test contains 20 randomly presented problems, 8 problems from Drill 12 and 6 from each of Drills 13 and 14.

Level 15 Given a one-place divisor and a dividend which is a multiple of the divisor, the student constructs the quotient.

Example: $2\overline{)824}$

Given a one-place divisor and a dividend which is *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $2\overline{)825}$

Level 16 Given a one-place divisor and a dividend which is a multiple of the divisor, the student constructs the quotient.

Example: $3\overline{)972}$

Given a one-place divisor and a dividend which is *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $2\overline{)835}$

Level 17 Given a one-place divisor and a dividend which is a multiple of 100 and a multiple of the divisor, the student constructs the quotient.

Examples: $4\overline{)600}$ $4\overline{)700}$

Given a one-place divisor and a dividend which is a multiple of the divisor, the student constructs the quotient.

Examples: $4\overline{)704}$ $5\overline{)605}$

Given a one-place divisor and a dividend which is *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $4\overline{)606}$

Review Test V

This test contains 20 randomly presented problems, 6 from Drill 15, 5 from Drill 16, and 9 from Drill 17.

Level 18 Given a one-place divisor and a dividend which is a multiple of ten and a multiple of the divisor, the student constructs the quotient.

Examples: $7\overline{)840}$ $4\overline{)780}$

Given a one-place divisor and a dividend which is a multiple of ten but *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $7\overline{)830}$

Given a one-place divisor and a dividend which is *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $7\overline{)847}$

Given a one-place divisor and a dividend which is *not* a multiple of the divisor, the student constructs the quotient, which is a multiple of ten, and the remainder.

Example: $7\overline{)841}$

Level 19 Given a one-place divisor and a dividend which is *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $5\overline{)656}$

Given a one-place divisor and a dividend which is a multiple of the divisor, the student constructs the quotient.

Example: $7\overline{)615}$

Given a one-place divisor and a dividend which is *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $7\overline{)813}$

Review Test VI

This test contains 20 randomly presented problems, 10 problems from each of Drills 18 and 19.

Division – Two-Place Divisors

Level 20 Given a divisor which is a multiple of ten and any two-place dividend where the the quotient is less than ten, the student constructs the quotient and the remainder.

Examples: $60\overline{)81}$ $40\overline{)90}$

Level 21 Given a divisor which is a multiple of ten and a three-place dividend where the quotient is less than ten, the student constructs the quotient and the remainder.

Examples: $70\overline{)234}$ $40\overline{)300}$

Level 22 Given a divisor which is a multiple of 10 and a 3-place dividend where the quotient is more than 10 and less than 100, the student constructs the quotient and the remainder.

Examples: $20\overline{)553}$ $30\overline{)800}$

Level 23 Given a divisor which is a multiple of 10 and a 4-place dividend where the quotient is at least 100, the student constructs the quotient and the remainder.

Examples: $90\overline{)9190}$ $30\overline{)6100}$

Level 24 Given a divisor which is a multiple of 10 and a 4-place dividend where the quotient is at least 10 and less than 100, the student constructs the quotient and the remainder.

Examples: $30\overline{)2126}$ $60\overline{)3300}$

Review Test VII

This test contains 20 randomly presented problems, 4 from each of Drills 20–24. Divisors are all multiples of 10; dividends are 2-, 3- and 4-place numerals.

Rounding Numerals to the Nearest Ten

Objective 1 Given a number between 10 and 100 which is not a multiple of 5 and given a number line which represents the interval of 10 between which the number comes, the student identifies the multiple of 10 that the number is nearer.

Example: Point to the correct answer on the number line.

48 is closer to which of these 2 multiples of 10?

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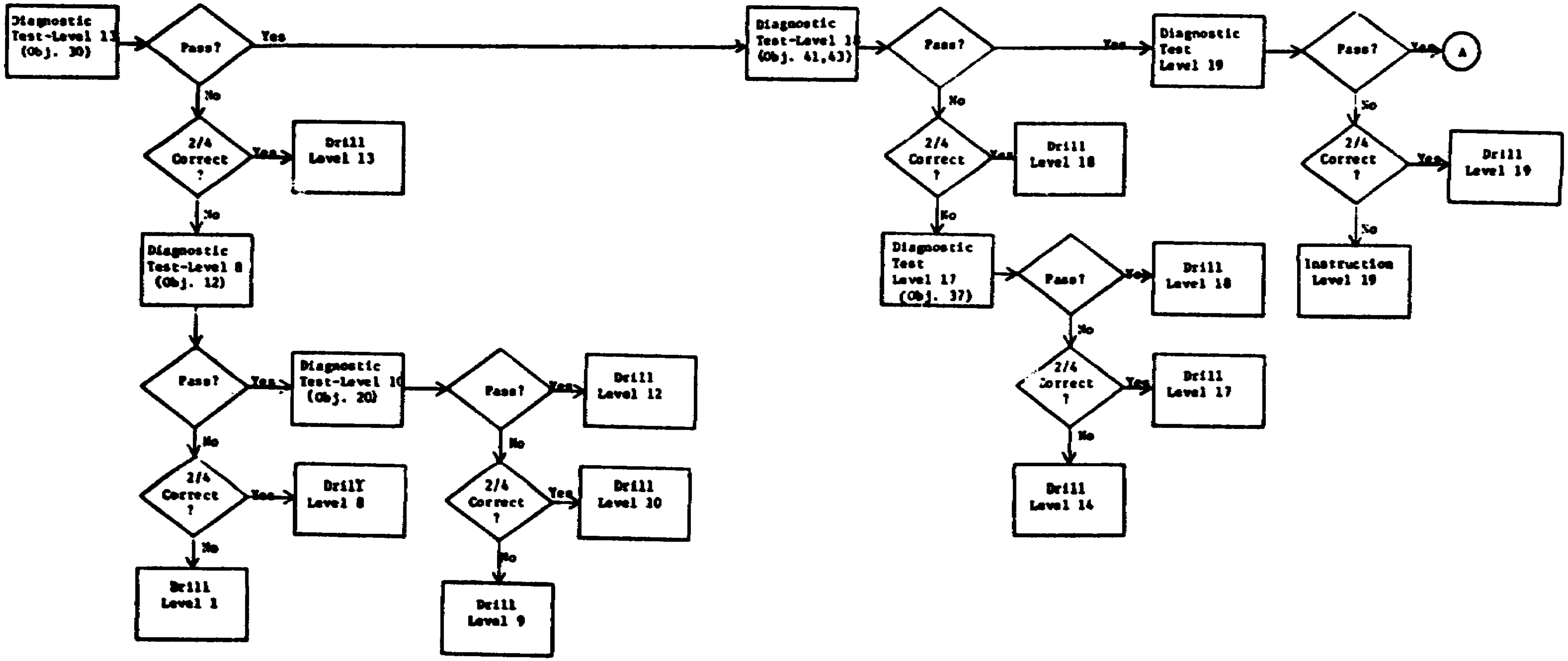
OPERATION WHOLE NUMBERS

Division Pretest Strategy in One-Place Divisors



A = Survey Test I - Two-place Divisors

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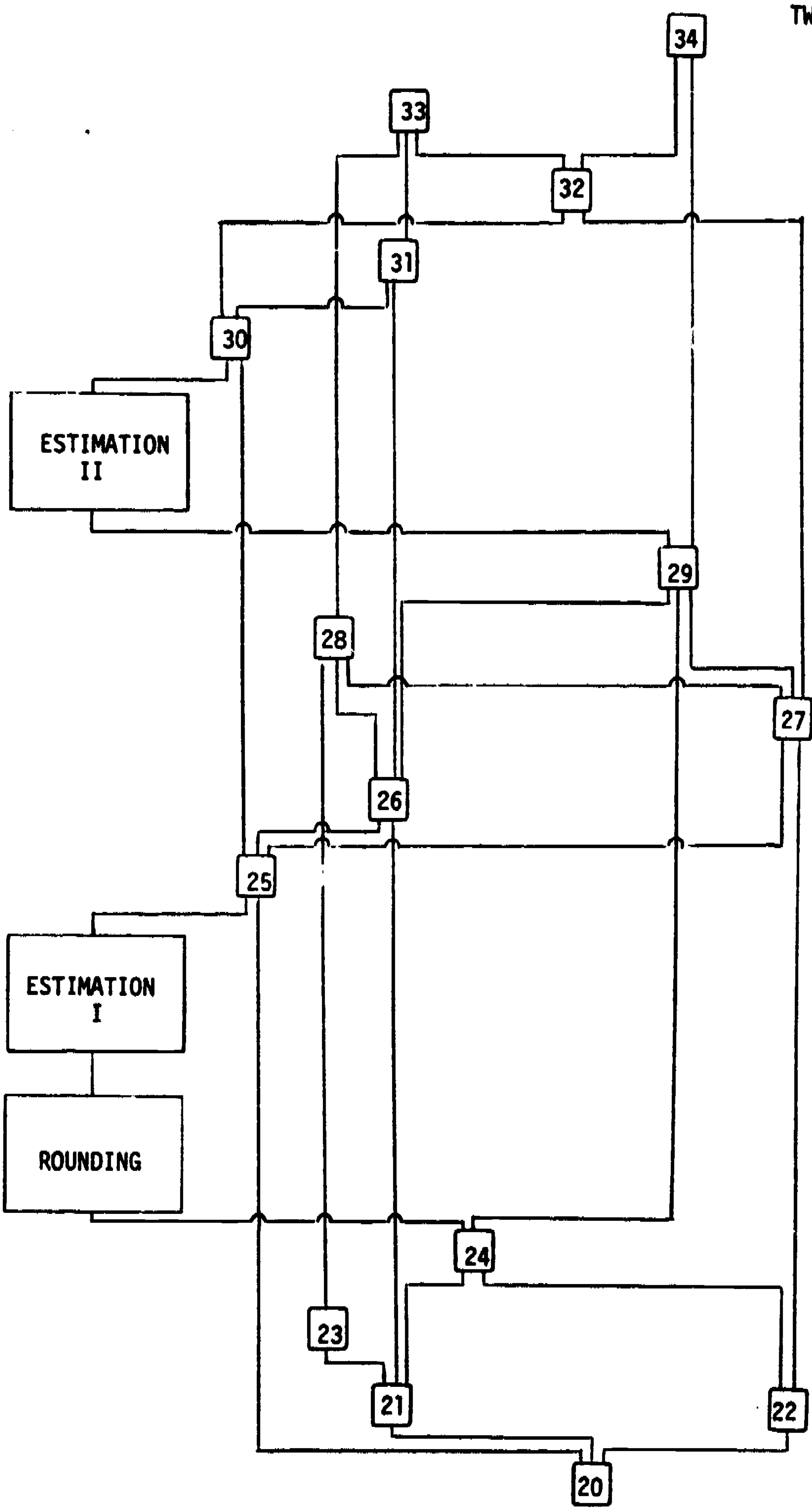
DIVISION HIERARCHY
TWO-PLACE DIVISORS



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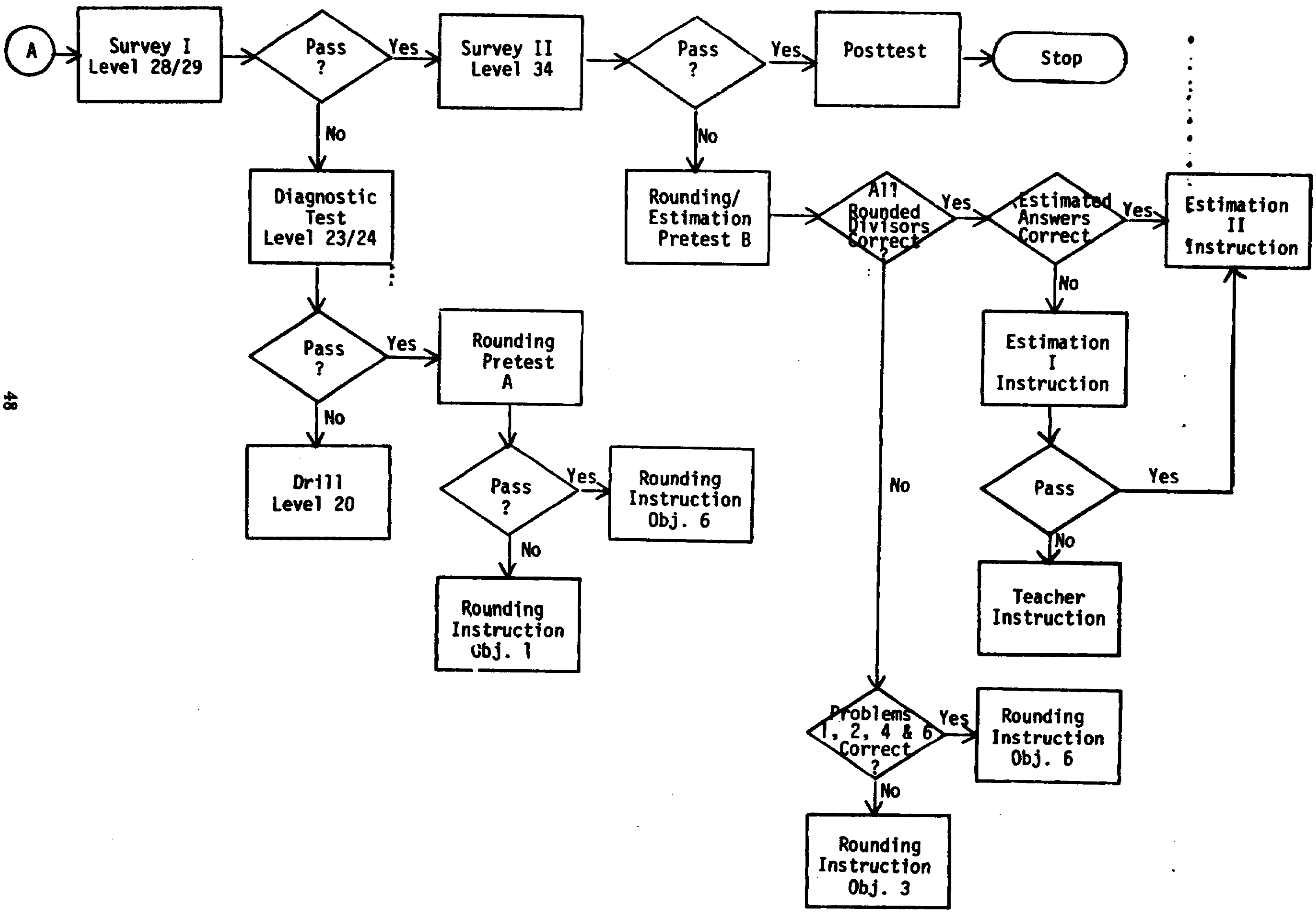
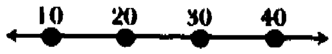
Division Pretest Strategy - Two-place Divisors



Objective 2 Given a number between 10 and 100 which is not a multiple of 5 and given a number line on which at least 4 multiples of 10 are named, the student names the 2 multiples of ten between which the number comes.

Example: Use your number line to help answer these questions.



23 comes between 2 multiples of 10.
23 comes between _____ and _____. Type your answer.

Objective 3 Given a number between 10 and 100 which is not a multiple of 5, the student names the multiples of 10 between which the number comes.

Example: Use the keys to type your answer.

88 comes between 2 multiples of 10.
88 comes between _____ and _____.

Objective 4 Given a number between 10 and 100 which is not a multiple of 5, the student names the closest multiple of 10.

Example: 53 is closer to 1 multiple of 10 than to any other multiple of 10.
53 is closer to _____. Type your answer.

Objective 5 Given a number between 10 and 100 which is not a multiple of 5, the student rounds the number to the nearest 10.

Example: Round each of these numerals to the nearest 10.
63 is rounded to _____.

Objective 6 Given a multiple of 5 between 10 and 100 which is not also a multiple of 10, the student rounds the number to the higher 10.

Example: Round each of these numerals to the nearest 10.
25 is rounded to _____. Type your answer.

Objective 7 Given a number between 10 and 100 which is not a multiple of 10, the student (a) rounds to the lower multiple of 10 when the number in the ones place is ≤ 4 and (b) rounds to the higher multiple of 10 when the number in the ones place is ≥ 5.

Example: Round this numeral to the nearest 10.
17 is rounded to _____. Type and enter your answer.

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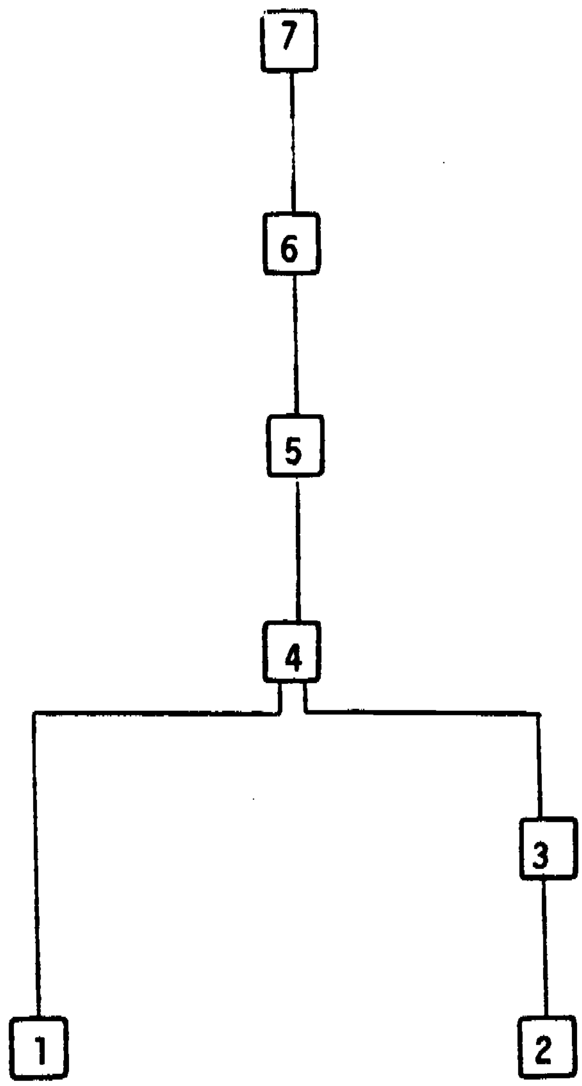
HIERARCHY FOR
ROUNDING NUMERALS TO THE NEAREST TEN



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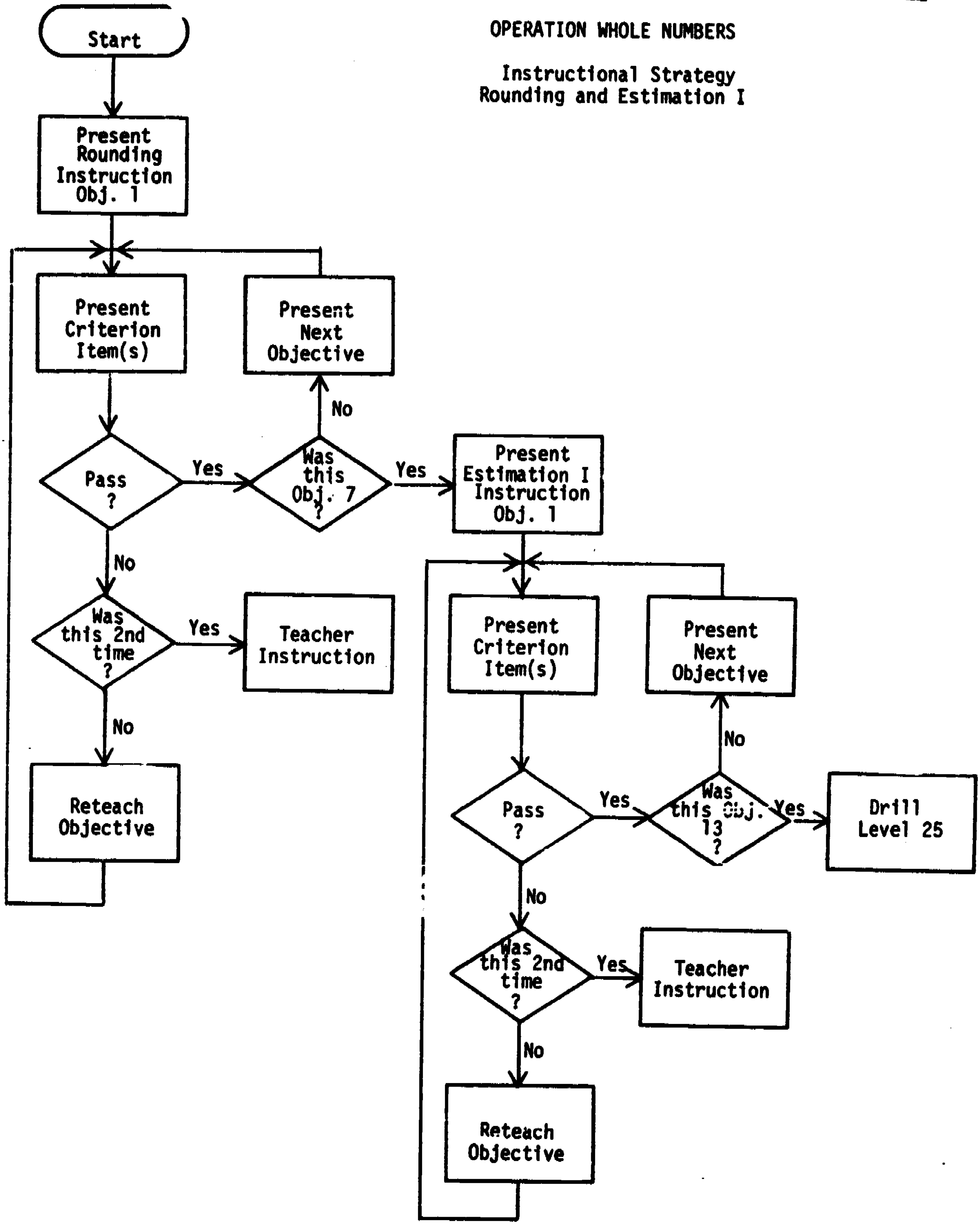
OPERATION WHOLE NUMBERS

Instructional Strategy
Rounding and Estimation I



Estimation – Part I

Objective 1 Given a division problem, the student identifies the divisor as the number to be rounded.

Example: $42\overline{)183}$

Using your light pen, point to the number that you would round to help solve this division problem.

Objective 2 Given a division problem, the student rounds the divisor to the nearest ten.

Example: $42\overline{)183}$

The rounded divisor is _____.
Type and enter your answer.

Objective 3 Given a division problem in which the quotient is less than ten, the student multiplies the rounded divisor by the natural numbers less than ten.

Example: $42\overline{)183}$

Multiply and find the products.
Type and enter your answer.

40 X 1 = _____	40 X 4 = _____	40 X 7 = _____
40 X 2 = _____	40 X 5 = _____	40 X 8 = _____
40 X 3 = _____	40 X 6 = _____	40 X 9 = _____

Objective 4 Given a division problem in which the quotient is greater than 9 but less than 100, the student multiplies the rounded divisor by the multiples of 10 less than 100.

Example: $58\overline{)3725}$

Multiply and find the products.
Type and enter your answer.

60 X 10 = _____	60 X 40 = _____	60 X 70 = _____
60 X 20 = _____	60 X 50 = _____	60 X 80 = _____
60 X 30 = _____	60 X 60 = _____	60 X 90 = _____

Objective 5 Given a division problem in which the quotient is greater than 99 but less than 1,000, the student multiplies the rounded divisor by the multiples of 100 less than 1,000.

Example: $29\overline{)9495}$

Multiply and find the products.
Type and enter your answer.

30 X 100 = _____	30 X 400 = _____	30 X 700 = _____
30 X 200 = _____	30 X 500 = _____	30 X 800 = _____
30 X 300 = _____	30 X 600 = _____	30 X 900 = _____

ESTIMATION I

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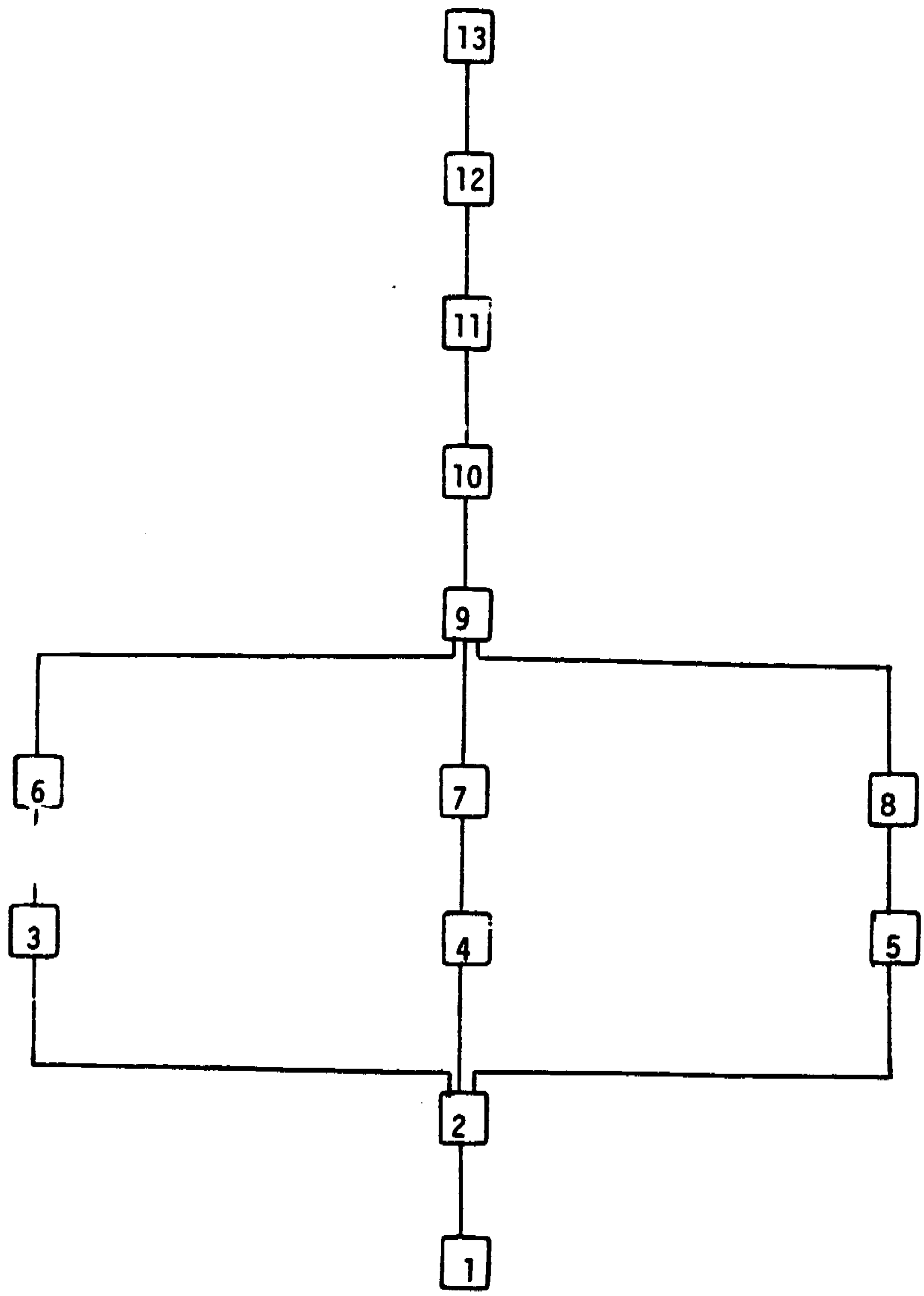
HIERARCHY



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Objective 6 Given a division problem, the products of the rounded divisor and the natural numbers less than ten, the student identifies the products which are less than the dividend.

Example: 42)183

40 X 1 = 40	40 X 4 = 160	40 X 7 = 280
40 X 2 = 80	40 X 5 = 200	40 X 8 = 320
40 X 3 = 120	40 X 6 = 240	40 X 9 = 360

Using your light pen, point to the multiplication facts whose *products* are less than the *dividend.*

Objective 7 Given a division problem, the products of the rounded divisor and the multiples of 10 less than 100, the student identifies those products which are less than the dividend.

Example: 58)3725

60 X 10 = 600	60 X 40 = 2400	60 X 70 = 4200
60 X 20 = 1200	60 X 50 = 3000	60 X 80 = 4800
60 X 30 = 1800	60 X 60 = 3600	60 X 90 = 5400

Using your light pen, point to the multiplication facts whose *products* are less than the *dividend.*

Objective 8 Given a division problem, the products of the rounded divisor and the multiples of 100 less than 1,000, the student identifies those products which are less than the dividend.

Example: 29)9495

30 X 100 = 3000	30 X 400 = 12,000	30 X 700 = 21,000
30 X 200 = 6000	30 X 500 = 15,000	30 X 800 = 24,000
30 X 300 = 9000	30 X 600 = 18,000	30 X 900 = 27,000

Using your light pen, point to the multiplication facts whose *products* are less than the *dividend.*

Objective 9 Given a division problem and the multiplication facts whose products are less than the dividend, the student identifies the product which is closest to the dividend.

Example: 42)183

40 X 1 = 40	40 X 3 = 120
40 X 2 = 80	40 X 4 = 160

Using your light pen, point to the multiplication fact whose product is closest to the dividend in this division problem.

58)3725

60 X 10 = 600	60 X 40 = 2400
60 X 20 = 1200	60 X 50 = 3000
60 X 30 = 1800	60 X 60 = 3600

Using your light pen, point to the multiplication fact whose product is closest to the dividend in this division problem.

29)9495
30 X 100 = 3000
30 X 200 = 6000
30 X 300 = 9000

Using your light pen, point to the multiplication fact whose product is closest to the dividend in this division problem.

Objective 10 Given a division problem, the student names the factor whose product with the rounded divisor is closest to the dividend as the estimated quotient.

Example: 42)183

The estimated quotient is _____.
Type and enter your answer.

58)3725

The estimated quotient is _____.
Type and enter your answer.

29)9495

The estimated quotient is _____.
Type and enter your answer.

Objective 11 Given a division problem and the estimated quotient, the student multiplies the estimated quotient by the actual divisor.

Example: 42)183
The estimated quotient is *4*.
42 X 4 = _____
Type and enter your answer.

58)3725
The estimated quotient is *60*.
58 X 60 = _____
Type and enter your answer.

29)9495
The estimated quotient is *300*.
29 X 300 = _____
Type and enter your answer.

Objective 12 Given a division problem, the product of the estimated quotient and the actual divisor, the student determines if the product is less than the dividend.

Example: 42)183
42 X 4 = 168

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Is the product of the divisor and the estimated quotient less than the dividend?

☐ yes ☐ no

$58\overline{)3725}$

$58 \times 60 = 3480$

Is the product of the divisor and the estimated quotient less than the dividend?

☐ yes ☐ no

$29\overline{)9495}$

$29 \times 300 = 8700$

Is the product of the divisor and the estimated quotient less than the dividend?

☐ yes ☐ no

Objective 13 Given a division problem with a one-, two-, or three-place quotient, the student solves the problem by using the rounded divisor to estimate the quotient.

Example: $42\overline{)183}$

The rounded divisor is *40*.

The estimated quotient is *4*.

Work this problem.

$$\begin{array}{r} 4\ \text{R}15 \\ 42\overline{)183} \\ \underline{168}\ (42 \times 4) \\ 15 \end{array}$$

$58\overline{)3725}$

The rounded divisor is *60*.

The estimated quotient is *60*.

Work this problem.

$$\begin{array}{r} 64\ \text{R}13 \\ 58\overline{)3725} \\ \underline{3480} \\ 245 \\ \underline{232} \\ 13 \end{array}$$

$29\overline{)9495}$

The rounded divisor is *30*.

The estimated quotient is *300*.

Work this problem.

$$\begin{array}{r} 327\ \text{R}12 \\ 29\overline{)9495} \\ \underline{8700} \\ 795 \\ \underline{580} \\ 215 \\ \underline{203} \\ 12 \end{array}$$

The estimated quotient is part of the correct answer in all problems in Drills 25–29.

Level 25 Given a two-place divisor *not* a multiple of ten and a two-place dividend, the student constructs the quotient and the remainder.

Examples: $19\overline{)73}$ $25\overline{)80}$

Level 26 Given a two-place divisor *not* a multiple of ten and a three-place dividend, the student constructs the one-place quotient and the remainder.

Examples: $53\overline{)113}$ $38\overline{)206}$

Level 27 Given a two-place divisor *not* a multiple of ten and a three-place dividend, the student constructs the two-place quotient and the remainder.

Examples: $85\overline{)900}$ $29\overline{)853}$

Level 28 Given a two-place divisor *not* a multiple of ten and a four-place dividend, the student constructs the two-place quotient and the remainder.

Examples: $44\overline{)6708}$ $69\overline{)8000}$

Level 29 Given a two-place divisor *not* a multiple of ten and a four-place dividend, the student constructs the two-place quotient and the remainder.

Examples: $38\overline{)2400}$ $22\overline{)1123}$

Review Test VIII

This test contains 20 randomly presented problems, 4 from each of Drills 25–29. Divisors are two-place but not multiples of ten. Dividends are two-, three-, and four-place numerals.

Estimation – Part II

Objective 1 Given a two-place divisor not a multiple of ten and a two- or three-place dividend, the student estimates the quotient and identifies that the estimated quotient is too large to be part of the correct answer or he names the correct quotient.

Example: $23\overline{)186}$
The divisor is rounded to _____.
The estimated quotient is _____.

23 X 9 = _____
The estimated quotient is
too large
too small

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Objective 2 Given a two-place divisor not a multiple of ten and a two- or three-place dividend, the student estimates the quotient and identifies that the estimated quotient is too small to be part of the correct answer or he names the correct quotient.

Example: $26\overline{)162}$

The divisor is rounded to _____.

The estimated quotient is _____.

26 X 5 = _____

The estimated quotient is

too large

too small

Objective 3 Given a two-place divisor not a multiple of ten and a two- or three-place dividend, the student estimates the quotient and identifies whether the estimated quotient is part of the correct answer or too large or too small to be part of the correct answer.

Example: $34\overline{)223}$

The divisor is rounded to _____.

The estimated quotient is _____.

34 X _____ = _____

Therefore, the estimated quotient is

too large

too small

part of the correct answer

Level 30 Given a two-place divisor *not* a multiple of ten and a two-place dividend, the student constructs the quotient and the remainder.

Examples: $26\overline{)78}$ $19\overline{)96}$

Level 31 Given a two-place divisor *not* a multiple of ten and a three-place dividend, the student constructs the one-place quotient and the remainder.

Examples: $59\overline{)238}$ $74\overline{)640}$

Level 32 Given a two-place divisor *not* a multiple of ten and a three-place dividend, the student constructs the two-place quotient and the remainder.

Examples: $24\overline{)804}$ $49\overline{)936}$

Level 33 Given a two-place divisor *not* a multiple of ten and a four-place dividend, the student constructs the three-place quotient and the remainder.

Examples: $43\overline{)7217}$ $88\overline{)9587}$

Level 34 Given a two-place divisor *not* a multiple of ten and a four-place dividend, the student constructs the two-place quotient and the remainder.

Examples: $33\overline{)2800}$ $18\overline{)1548}$

OPERATION WHOLE NUMBERS

Instructional Strategy
Estimation II

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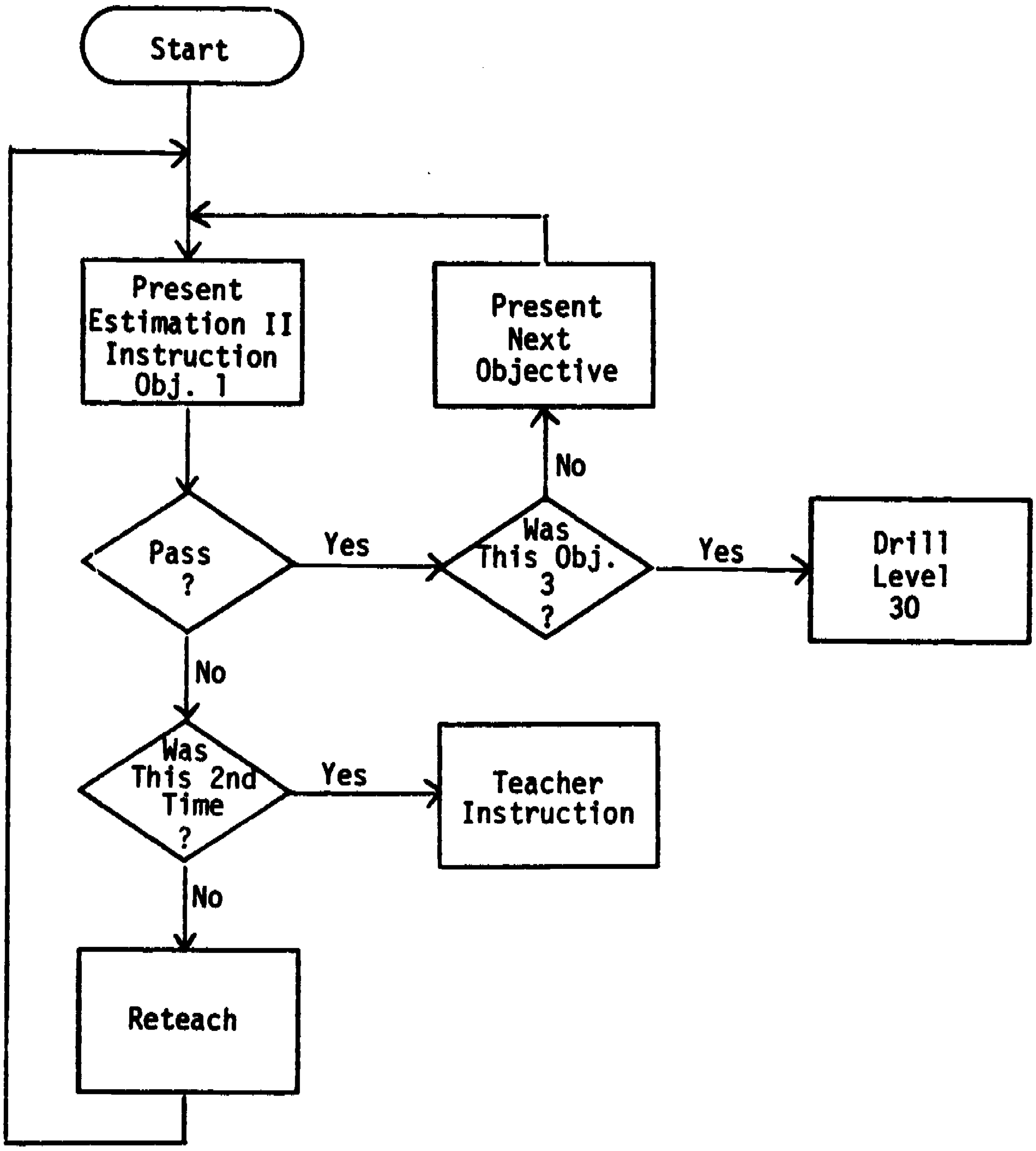

Review Test IX

This test contains 20 randomly presented problems, 4 from each of Drills 30–34. Divisors are two-place but not multiples of ten. Dividends are two-, three-, and four-place numerals.

2. Sign-on Fractions

Originally SIGN-ON FRACTIONS consisted of 39 drill exercises, 19 in addition and 20 in subtraction, which were grouped according to related skills in an author-arranged program. Although this program provided elementary students with the practice necessary for skill development in fractions, it did not meet the individual needs of the students. Each student using the program entered at the same point and was required to work each drill in its arranged sequence. This proved to be an inefficient use of student time and necessitated certain modifications to be made. A series of concept tests and a diagnostic sequence were added to the original drill program making it a valid package for use in the upper elementary grades.

To insure that students have the fractional concepts required for working the drill problems, 7 concept tests containing a total of 16 objectives were written and placed at appropriate intervals in the drill sequence. Each concept test serves as an entering behaviors test for the following drill sequence. This module has proved successful as a developmental program in beginning fractional concepts.

To make the program more useful for sixth grade students, a diagnostic sequence was arranged so that a student could enter the concept test/drill sequence at the level determined by his individual concept and skill needs. This modification, Version II of the program, has insured a more efficient use of student and computer time in the sixth grade.

Whether the student enters SIGN-ON FRACTIONS at Concept Test I or a point determined by the diagnostic testing, he progresses through the program in a controlled sequence to attain the two terminal objectives:

1. Given two fractions or two mixed numerals with unlike denominators, for which the lowest common denominator is not one of the denominators or their product and whose fractional sum is greater than one, the student writes the sum in its simplest form.*

2. Given two mixed numerals or a mixed numeral and a fraction with unlike denominators, for which the lowest common denominator is not one of the denominators or their product, the student writes the difference in its simplest form.*

SIGN-ON FRACTIONS, Version II, consists of 1 survey test; 5 diagnostic tests; 7 concept tests; 39 drills, 19 of which provide practice in addition of fractions and 20 in subtraction; and a posttest.

Diagnostic Sequence

The complete fraction diagnostic sequence includes the survey test, five diagnostic tests, and three of the concept tests. In the survey and diagnostic tests, the student works each problem on paper and types only his final answer in simplest form. If he does not know how to do the problem, he has the option of typing an "X," which counts as a wrong answer but allows him to continue in the program.

*The whole numbers do not exceed 9, and the denominators of the fractions do not exceed 16.

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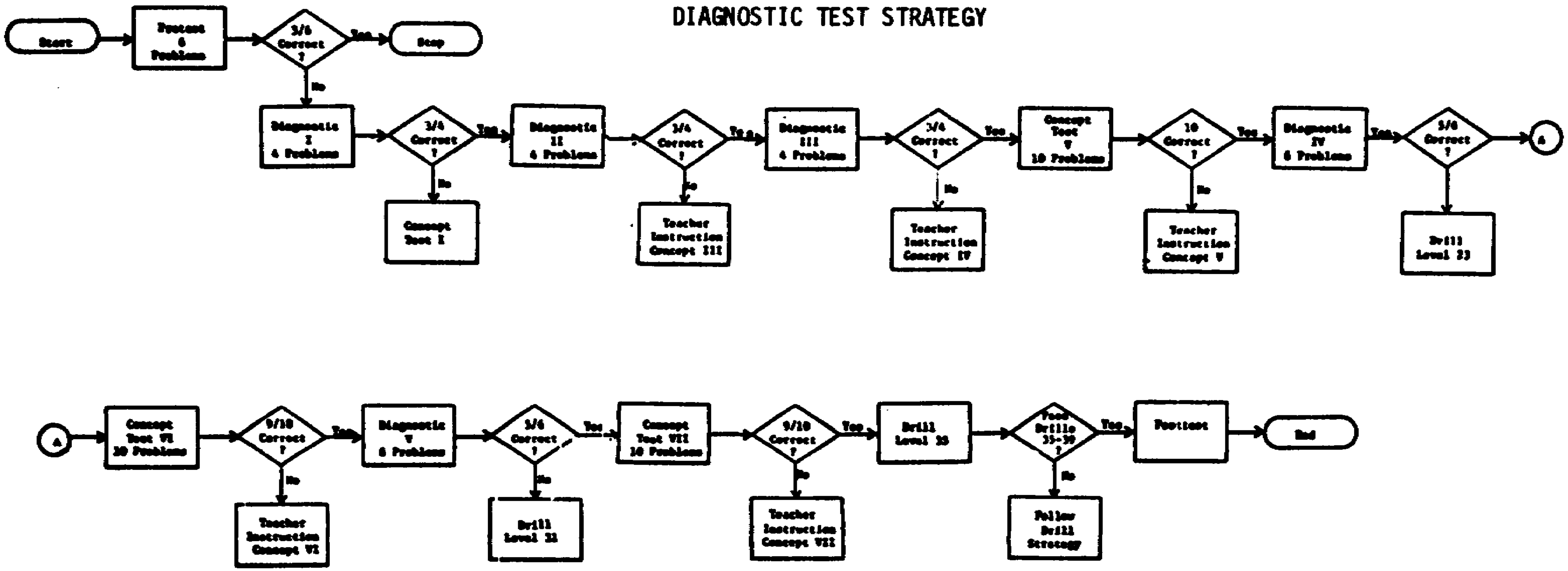
SIGN-ON FRACTIONS

VERSION II

DIAGNOSTIC TEST STRATEGY



Survey Test

The survey consists of six problems, three from each of Drills 38 and 39, the terminal objectives. To demonstrate mastery of the concepts and skills presented in the program and pass the survey test, the student must answer correctly five of the six problems.

Diagnostic Test I

The student who does not pass the survey is branched to Diagnostic Test I, which contains four problems, one from each of Drills 9 through 12. To pass and proceed to Diagnostic Test II, he must answer correctly three of the four problems. If he does not pass, he is placed in Concept Test I, the beginning of the concept test/drill sequence.

Diagnostic Test II

This test contains four problems, one from each of Drills 13 through 16. To pass and proceed to Diagnostic Test III, the student must answer correctly three of the four problems. If he does not pass, he receives teacher instruction on the concepts presented in Concept Test III. When he returns to work with the computer, he enters Concept Test III in the concept test/drill sequence.

Diagnostic Test III

This test contains four problems, two from Drill 19 and one from each of Drills 21 and 22. To pass, the student must answer correctly three of the four problems. If he passes, he proceeds to Concept Test V. If he does not pass, he receives teacher instruction on the concepts presented in Concept Test IV and then enters Concept Test IV in the concept test/drill sequence.

Concept Test V

This test includes ten questions, five of which ask for fractional equivalents for a fraction given with the ordinal of its equivalent. The other five questions ask for the lowest common denominator for two given fractions with unlike denominators, one denominator being a factor of the other. To pass, the student must answer all ten items correctly. The student who does not pass receives teacher instruction and enters this concept test in the concept test/drill sequence.

Diagnostic Test IV

In the diagnostic sequence, the student who passes Concept Test V is branched to Diagnostic Test IV, which contains six problems, two from each of Drills 24 and 25 and one from each of Drills 26 and 30. To pass and proceed to Concept Test VI, the student must answer correctly five of the six problems. If he does not pass, he enters Drill level 23.

Concept Test VI

This test contains ten questions, all of which must be answered correctly to pass to Diagnostic Test V. The student is given two fractions with unlike denominators whose lowest common denominator is the product of the denominators and is asked to name the lowest common denominator. The student who does not pass receives teacher instruction and enters Concept Test VI in the concept test/drill sequence.

Diagnostic Test V

This test contains six problems, three from each of Drills 33 and 34. Five correct answers constitute passing to Concept Test VII. The student who does not pass enters the drill sequence at Level 31.

Concept Test VII

This test contairs ten questions, all of which must be answered correctly to pass. The student is given two fractions with unlike denominators whose lowest common denominator is not one of the denominators or their product and is asked to name the lowest common denominator. The student who passes enters the drill sequence at Level 35. The student who does not pass receives teacher instruction and returns to this concept test.

Program Sequence

Used without the diagnostic testing, the program becomes developmental with the student progressing through a series of concept test and drill sequences.

Concept Tests

Seven concept tests, containing questions which determine whether or not a student has the basic learning(s) necessary for working the drill problems which follow the test, are interspersed among 39 drills. The concept test objectives include writing equivalents for fractions, whole numbers, and mixed numerals; simplifying fractions and mixed numerals; and naming the lowest common denominator. In each concept test, the student must answer all ten items correctly to pass into the drill sequence. The student who does not pass receives teacher instruction.

Drills

The 19 addition drills and 20 subtraction drills are each designed to contain only one new learning and are presentedin a developmental sequence alternating addition and subtraction drills. Most drills contain ten problems; fourteen drills at the end of the program contain only five problems.

To pass a drill, the student must answer correctly nine of the ten or four of the five problems. If he misses two problems on his first attempt, he repeats the drill. If he misses three or more problems on his first attempt, he is branched for teacher instruction before he repeats the drill. If the student fails the drill on his second attempt, he receives teacher instruction.

In each problem in a drill, the student is given two attempts to type in the correct final answer *or* the answer to one of the steps leading to the final answer. If his first answer is incorrect, he is told, "No. Try again." If his second answer is incorrect, he will be given the correct answer and *must* type it in before proceeding. At this point, the problem is counted wrong.

Posttest

A posttest containing six problems, three addition and three subtraction based on the terminal objectives and presented in alternating sequence, completes the program. The student works each problem on paper and types only his final answer in the simplest form.

PROGRAM SEQUENCE

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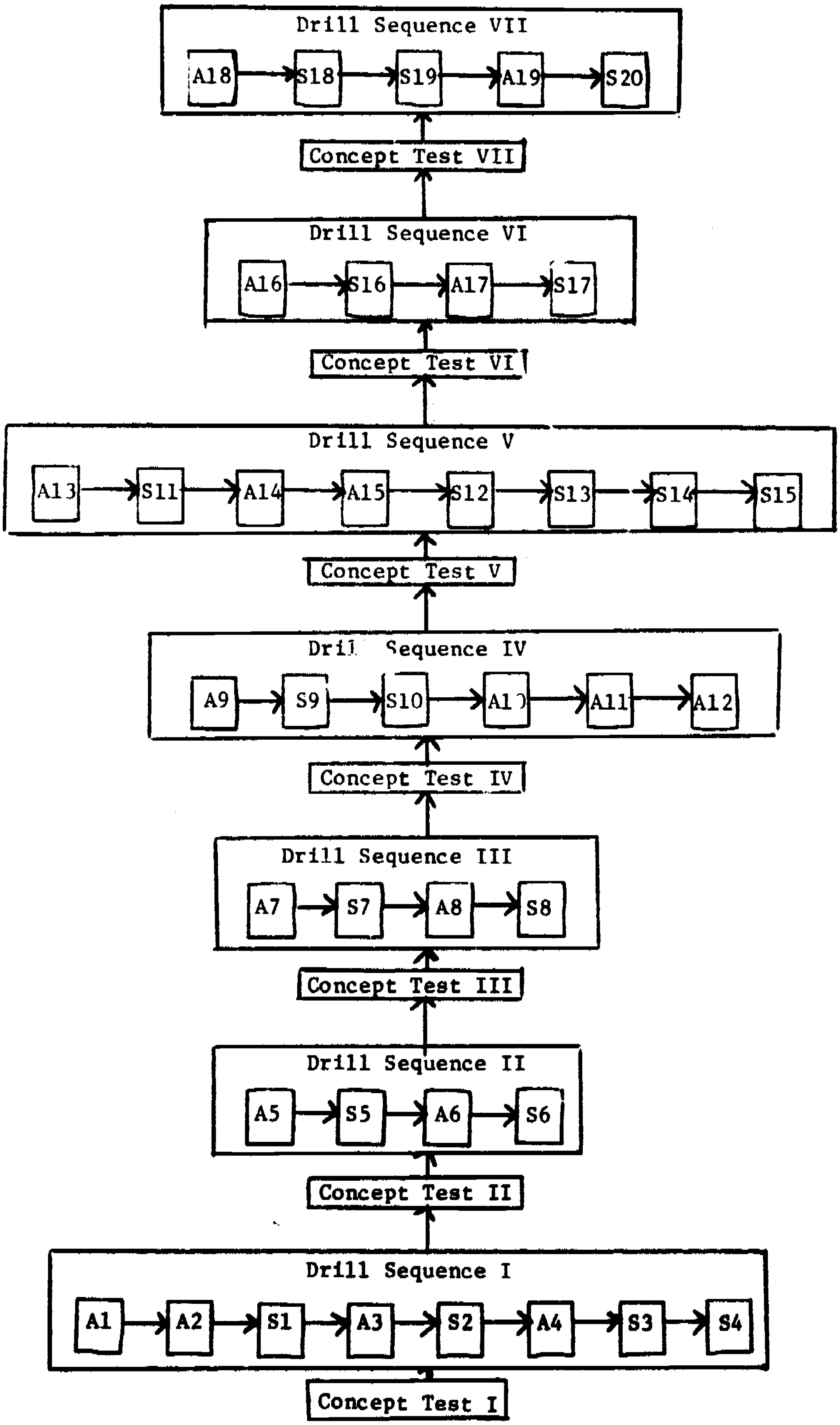
SIGN-ON FRACTIONS



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Concept Test I

Before entering Drill Sequence I, the student will be tested on the following fractional concepts:

Objective A

Given an illustration of a plane figure divided into less than ten equal parts with one or more of the parts shaded, the student writes the fraction represented by the shaded parts.

Example: What fractional part is represented by the shaded part of this shape?

Objective B

Given an illustration consisting of 12 or less identical objects, some of which are enclosed by line segments, the student writes the fraction represented.

Example: What fractional part of the objects is enclosed in this drawing?

Five items on each objective are presented. The student must answer correctly all items in order to enter the drills.

Drill Sequence I

All fractional numerals and mixed numerals in this drill sequence have like denominators and are in simplest form. Their sums or differences do not require simplification.

The objectives in Drill Sequence I are:

A1 Given a whole number and a fraction, the student writes the sum.

$$2 + \frac{3}{8} = 2\frac{3}{8}$$

A2 Given two fractions whose sum is less than one, the student writes the sum.

$$\frac{1}{5} + \frac{3}{5} = \frac{4}{5}$$

SIGN-ON FRACTIONS

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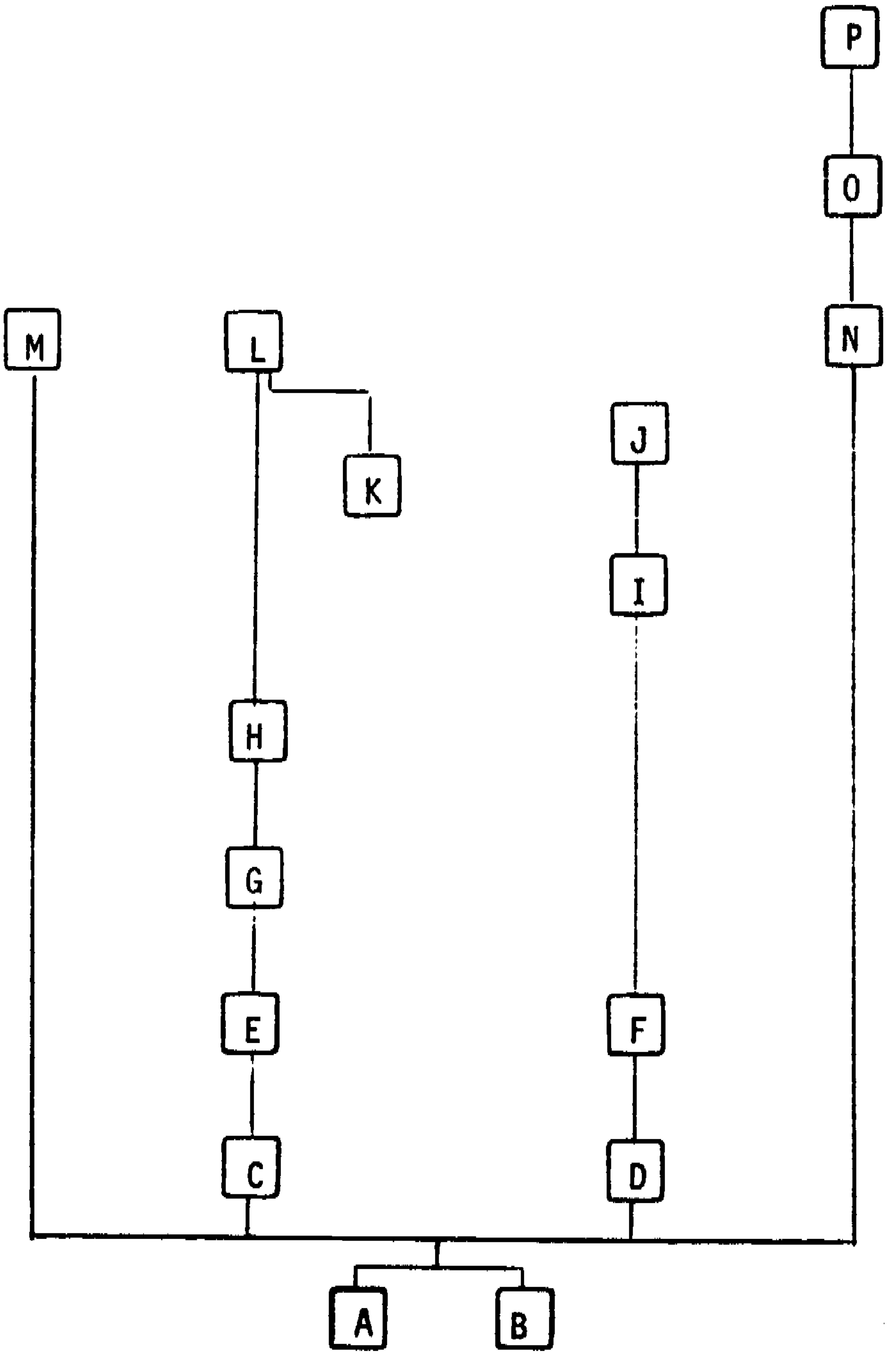
CONCEPT OBJECTIVES HIERARCHY



S1 Given two fractions, the student writes the difference.

$$\frac{4}{5} - \frac{1}{5} = \frac{3}{5}$$

A3 Given a mixed numeral and a fraction, the student writes the sum.

$$2\frac{3}{7} + \frac{2}{7} = 2\frac{5}{7}$$

S2 Given a mixed numeral and a fraction, the student writes the difference.

$$2\frac{4}{5} - \frac{1}{5} = 2\frac{3}{5}$$

A4 Given two mixed numerals, the student writes the sum.

$$3\frac{1}{5} + 2\frac{2}{5} = 5\frac{3}{5}$$

S3 Given two mixed numerals, the student writes the difference.

$$2\frac{4}{5} - 1\frac{3}{5} = 1\frac{1}{5}$$

S4 Given two mixed numerals whose difference is a whole number, the student writes the difference.

$$2\frac{4}{5} - 1\frac{4}{5} = 1$$

Concept Test II

Objective C

Given the fractions $\frac{2}{2}, \frac{3}{3}, \frac{4}{4}, \frac{5}{5} \ldots \frac{15}{15}$, the student names the whole number equivalent.

Example: $\frac{7}{7} = 1$

Objective D

Given the whole number 1 and the ordinal of the equivalent, the student names its fractional equivalent.

Example: $1 = \frac{6}{6}$

SIGN-ON FRACTIONS

ADDITION HIERARCHY

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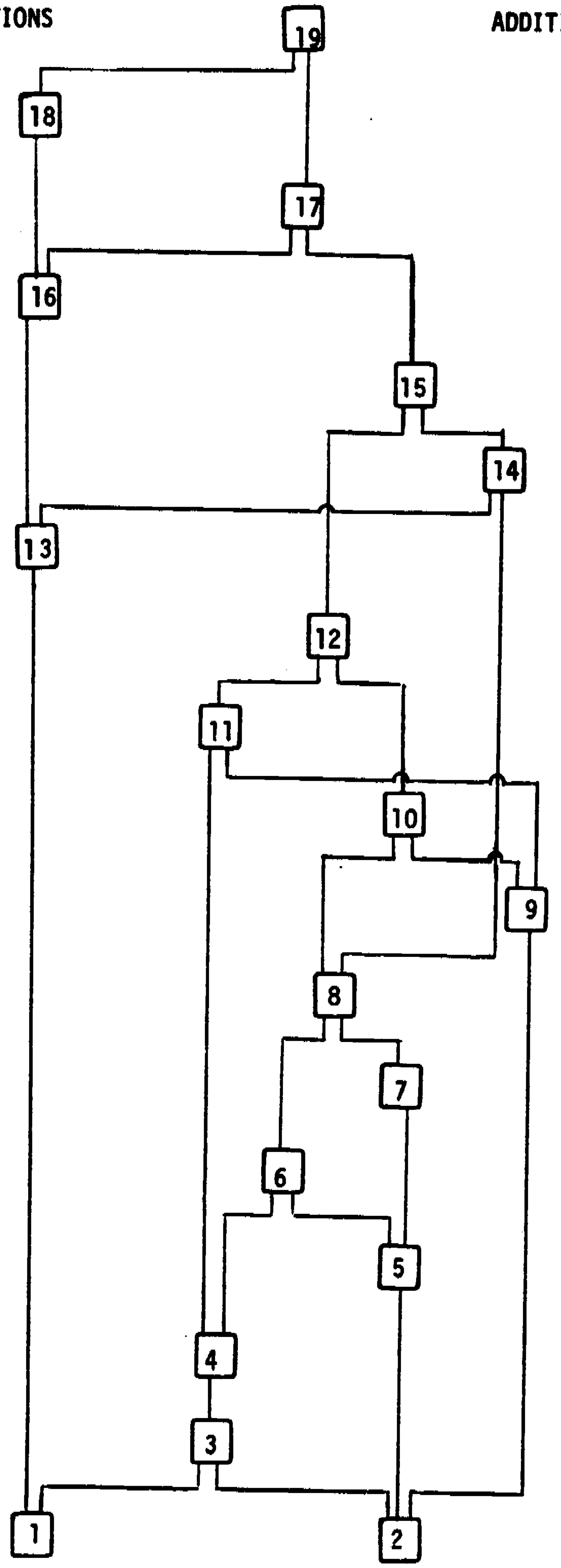

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Objective E

Given the mixed numerals $1\frac{2}{2}$, $2\frac{2}{2}$, $3\frac{4}{4}$, $5\frac{5}{5}$, . . . $9\frac{7}{7}$, the student names the whole number equivalent.

Example: $5\frac{4}{4} = 6$

Objective F

Given a whole number 1 to 9 and the ordinal of the equivalent, the student names the fractional equivalent.

Example: $4 = 3\frac{3}{3}$

<u>**Drill Sequence II**</u>

All fractional numerals and mixed numerals in this drill sequence have like denominators and are in simplest form. Sums are expressed as fractional names for whole numbers prior to being simplified. Differences do not require simplification.

The objectives in Drill Sequence II are:

A5 Given two fractions, the student writes the sum.

$$\frac{3}{4} + \frac{1}{4} = \frac{4}{4} = 1$$

S5 Given the whole number one and a fraction, the student writes the difference.

$$1 - \frac{1}{3} = \frac{2}{3}$$

A6 Given two mixed numerals, the student writes the sum.

$$3\frac{3}{4} + 1\frac{1}{4} = 4\frac{4}{4} = 5$$

S6 Given a whole number greater than one and a fraction, the student writes the difference.

$$6 - \frac{3}{5} = 5\frac{2}{5}$$

<u>**Concept Test III**</u>

Objective G

Given a fractional numeral greater than one, the student names the mixed numeral equivalent.

Example: $\frac{9}{7} = \square\frac{\square}{\square}$

Objective H

Given a mixed numeral whose fractional part is greater than one, the student names the mixed numeral in simplest form.

Example: $2\frac{7}{5} = \square\frac{\square}{\square}$

Objective I

Given a mixed numeral in which the whole number is always one, the student names the fractional equivalent.

Example: $1\frac{4}{5} = \square\frac{\square}{\square}$

Objective J

Given a mixed numeral and its equivalent in which the new integral part is one less than the original, the student names the fractional equivalent.

Example: $7\frac{2}{5} = 6\frac{\square}{5}$

<u>Drill Sequence III</u>

All fractional numerals and mixed numerals in this drill sequence have like denominators and are in simplest form. The sums need to be rewritten as mixed numerals.

The objectives in the Drill Sequence III are:

A7 Given two fractions, the student writes the sum.

$$\frac{4}{5} + \frac{3}{5} = \frac{7}{5} = 1\frac{2}{5}$$

S7 Given a mixed numeral in which the whole number is one and a fraction, the student writes the difference.

$$1\frac{2}{5} - \frac{4}{5} = \frac{3}{5}$$

A8 Given two mixed numerals or a mixed numeral and a fraction, the student writes the sum.

$$2\frac{4}{7} + 2\frac{5}{7} = 4\frac{9}{7} = 5\frac{2}{7}$$

S8 Given two mixed numerals or a mixed numeral and a fraction, the student writes the difference.

$$7\frac{2}{5} - 5\frac{4}{5} = 1\frac{3}{5}$$

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SIGN-ON FRACTIONS

SUBTRACTION HIERARCHY

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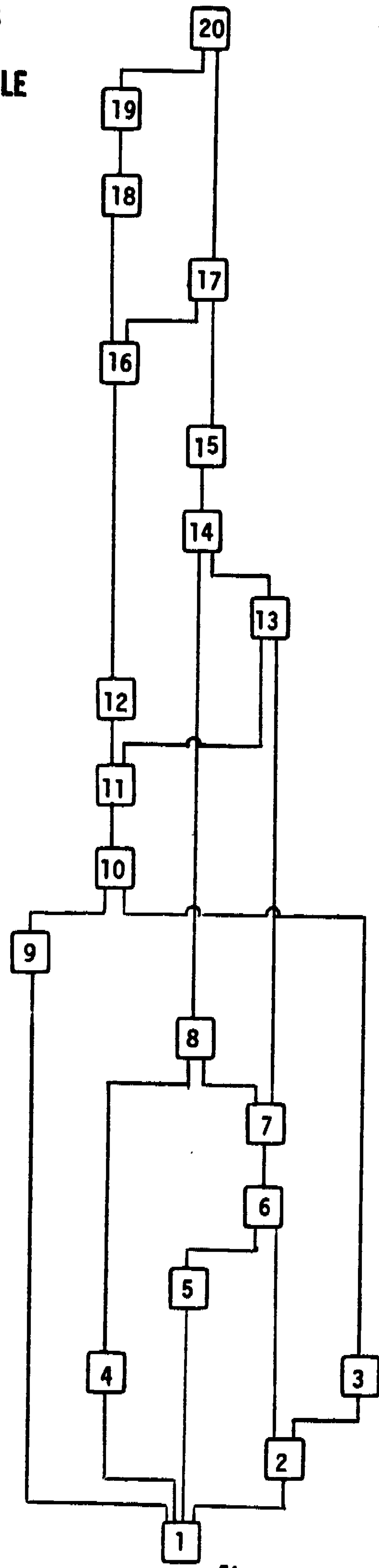

Concept Test IV

Objective K

Given a fraction, the student renames that fraction in its simplest form.

Example: $\frac{2}{4} = \frac{\square}{\square}$

Objective L

Given a fraction, the student writes the mixed numeral equivalent in its simplest form.

Example: $\frac{6}{4} = \square\frac{\square}{\square}$

Drill Sequence IV

All fractional numerals and mixed numerals in this drill sequence have like denominators and are in simplest form. Their sums or differences must be simplified.

The objectives in Drill Sequence IV are:

A9 Given two fractions whose sum is less than one, the student writes the sum.

$$\frac{1}{4} + \frac{1}{4} = \frac{2}{4} = \frac{1}{2}$$

S9 Given two fractional numerals whose difference is less than one, the student writes the difference.

$$\frac{8}{9} - \frac{5}{9} = \frac{3}{9} = \frac{1}{3}$$

S10 Given two mixed numerals whose difference is greater than one, the student writes the difference.

$$9\frac{5}{6} + 3\frac{1}{6} = 6\frac{4}{6} = 6\frac{2}{3}$$

A10 Given two fractions whose sum is greater than one, the student writes the sum.

$$\frac{3}{4} + \frac{3}{4} = \frac{6}{4} = \frac{3}{2} = 1\frac{1}{2}$$

A11 Given two mixed numerals or a mixed numeral and a fraction, with the sum of their fractional numerals less than one, the student writes the sum.

$$2\frac{3}{8} + 1\frac{1}{8} = 3\frac{4}{8} = 3\frac{1}{2}$$

A12 Given two mixed numerals with the sum of their fractional numerals greater than one, the student writes the sum.

$$2\frac{7}{8} + 3\frac{5}{8} = 5\frac{12}{8} = 5\frac{3}{2} = 6\frac{1}{2}$$

Concept Test V

Objective M

Given a fraction in simplest form and the ordinal of an equivalent, the student names the missing numerator.

Example: $\frac{2}{5} = \frac{\square}{20}$

Objective N

Given two fractions with unlike denominators, one denominator being a factor of the other, the student names the lowest common denominator.

Example: $\frac{1}{2} + \frac{1}{4}$

The lowest common denominator is _____.

Drill Sequence V

All fractional numerals and mixed numerals in this drill sequence are in simplest form and have unlike denominators. The lowest common denominator in the problems is one of the denominators. The sums and differences may need to be simplified or rewritten as mixed numerals.

The objectives for Drill Sequence V are:

A13 Given two fractions or a mixed numeral and a fraction, the student writes the sum.

$$\frac{1}{2} + \frac{1}{4} = \frac{3}{4}$$

S11 Given two fractions or two mixed numerals, the student writes the difference.

$$7\frac{1}{2} - 3\frac{1}{4} = 4\frac{1}{4}$$

A14 Given two fractions or two mixed numerals whose fractional sum is greater than one, the student writes the sum.

$$\frac{5}{8} + \frac{1}{2} = \frac{9}{8} = 1\frac{1}{8}$$

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A15 Given two fractions or two mixed numerals, the student writes the sum which requires both simplifying and rewriting as a mixed numeral.

$$\frac{2}{3} + \frac{5}{6} = \frac{9}{6} = \frac{3}{2} = 1\frac{1}{2}$$

S12 Given two fractions, two mixed numerals, or a mixed numeral and fraction, the student writes the difference which requires simplifying.

$$3\frac{5}{6} - 2\frac{1}{2} = 1\frac{2}{6} = 1\frac{1}{3}$$

S13 Given a mixed numeral and a fraction whose difference is less than one, the student writes the difference.

$$1\frac{1}{4} - \frac{1}{2} = \frac{3}{4}$$

S14 Given a mixed numeral and a fraction, the student writes the difference where the difference is greater than one.

$$9\frac{1}{3} - \frac{5}{9} = 8\frac{7}{9}$$

S15 Given two mixed numerals, the student writes the difference which may require simplifying.

$$3\frac{1}{4} - 1\frac{1}{2} = 1\frac{3}{4}$$

Concept Test VI

Objective O

Given two fractions with unlike denominators whose lowest common denominator is the product of the denominators, the student names the lowest common denominator.

Example: $\frac{1}{4} + \frac{1}{3} =$

The lowest common denominator is ______.

Drill Sequence VI

All fractional and mixed numerals in this drill sequence have unlike denominators. and the lowest common denominator in the problems is the product of the denominators. Sums may need to be rewritten as mixed numerals. Differences do not require simplification.

The objectives in Drill Sequence VI are:

A16 Given two fractions or two mixed numerals whose fractional sum is less than one, the student writes the sum.

$$\frac{1}{4} + \frac{1}{3} = \frac{7}{12}$$

S16 Given two fractions, two mixed numerals, or a mixed numeral and a fraction, whose fractional difference is less than one, the student writes the difference.

$$2\frac{2}{3} - 1\frac{1}{4} = 1\frac{5}{12}$$

A17 Given two fractions or two mixed numerals, whose fractional sum is greater than one, the student writes the sum.

$$\frac{4}{5} + \frac{1}{2} = \frac{13}{10} = 1\frac{3}{10}$$

S17 Given two mixed numerals or a mixed numeral and a fraction, the student writes the difference.

$$3\frac{1}{4} - 1\frac{2}{3} = 1\frac{7}{12}$$

Concept Test VII

Objective P

Given two fractions with unlike denominators whose lowest common denominator is not one of the denominators or their product, the student names the lowest common denominator.

Example: $\frac{3}{10} + \frac{3}{8} =$
The lowest common denominator is ______.

Drill Sequence VII

All fractional numerals and mixed numerals in this drill sequence have unlike denominators and their lowest common denominator is not one of the denominators or their product. Sums may need to be rewritten as mixed numerals.

The objectives in Drill Sequence VII are:

A18 Given two fractions or two mixed numerals, whose fractional sum is less than one, the student writes the sum.

$$\frac{3}{10} + \frac{3}{8} = \frac{27}{40}$$

S18 Given two fractions, the student writes the difference.

$$\frac{7}{10} - \frac{3}{8} = \frac{13}{40}$$

S19 Given two mixed numerals or a mixed numeral and a fraction, the student writes the difference.

$$6\frac{7}{8} - 2\frac{5}{6} = 4\frac{1}{24}$$

A19 Given two fractions or two mixed numerals, whose fractional sum is greater than one, the student writes the sum.

$$\frac{1}{4} + \frac{9}{10} = \frac{23}{20} = 1\frac{3}{20}$$

S20 Given two mixed numerals, the student writes the difference.

$$7\frac{1}{9} - 2\frac{1}{6} = 4\frac{17}{18}$$

3. Learning About Per Cents

LEARNING ABOUT PER CENTS is a tutorial program providing initial instruction in changing common fractions and decimals to per cents and in changing per cents to common fractions and decimals. The package was designed for students in the upper elementary grades. Because of the limited number of students who have the necessary fractional concepts required as entering behaviors, the program has not been used extensively in the elementary school.

B. SECONDARY

1. Mathematics

The secondary mathematics modules developed by the CAI Program received extensive utilization from July 1, 1971, to June 30, 1974. Although the materials were carefully author-programmer-student debugged, occasional errors did occur in some answers. As these errors were observed, they were called to the attention of CAI staff members and corrected.

The following projects related to more extensive revisions will be separated as to (1) those related to CAI modules primarily used in the algebra curriculum and (2) the Computer-Managed Instruction Geometry (year-long) course of study.

During the summer of 1972, three mathematics teachers from the program high school participated in a three-week afternoon workshop to review and revise three of the MCPS developed algebra modules:

1. RATIO AND PROPORTION

2. FACTORING

3. SLOPE OF THE LINE

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In the Einstein Math Lab, eight computer terminals serve approximately 100 students daily. The lab is staffed with a teacher and a teacher assistant each period.

The procedure, working on-line with the original display guide frames, was designed to facilitate revisions and consisted of the following:

1. Determine what change was needed on a given frame and indicate the change on the appropriate display guide
2. Obtain approval for making the change
3. Take the display guides needing change to the systems manager for recoding
4. Follow up the recoding with on-line review to ascertain that the changes were made appropriately

The revisions suggested and implemented for the respective programs follow:

Ratio and Proportion

1. Additional images of an exemplary nature were incorporated into the existing flipbook.
2. Reference to particular images in the flipbook were coded by number.

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3. Grammatical corrections were made on several frames.

4. Additional alternate correct answers were included.

5. A brief remedial branch was written for the first section on direct variation. (Previously, students reviewed the same material for remediation.)

6. Proctor messages to the teacher were further detailed.

Factoring

1. Additional alternate correct answers were included.

2. Two posttest items were revised to measure more adequately the terminal objectives of the program.

3. The student scoreboard for the posttest was redesigned to include a presentation of the problems answered incorrectly.

Slope of the Line

1. The title frame was changed from "Finding the Slope of a Linear Equation" to "Finding the Slope of a Line."

2. All references to a student "manual" (originally containing a pretest of mathematical skills necessary for chemistry and physics students) were deleted.

3. The format of fractional presentations was changed from horizontal to vertical.

4. Additional alternate correct answers were included.

The Math Lab is "noisy and friendly" reports Sarah Burkholder, algebra, trigonometry, and geometry teacher at Einstein since the program's beginning in 1968.

Geometry

Development of the Computer-Managed Geometry Program was completed during the academic year 1971-1972. This consisted of determining the related readings and exercise assignments and developing and coding the criterion test items for the remaining five units:

VI. Similarity

VII. Circles

VIII. Construction and Loci

IX. Coordinates

X. Area and Volume

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The Newport Junior High School terminal room, connected to the computer by underground coaxial cable, was completed in June, 1972. Seventh grade students initially used the seven terminals for orientation later that month. Math classes were scheduled for terminal use in early September.

The complete year-long CMI Geometry Program now contains ten units. Computer-managed instruction in this program means that geometry students use the computer terminals for assessment immediately upon completion of specific objectives and receive instant feedback, positive reinforcement, if correct, and prescriptions for remediation or for continuing their studies. Two alternate forms of assessment items are available for each objective. A test on the terminal objectives of each unit has been developed and is randomly generated from a bank of test items. As an example of the CMI Geometry Module, Objectives 5, 6, and 7 from Unit 4, Parallels and Perpendiculars, are shown below with assessment items for each objective.

Objective 5

Apply the rules for parallelism (in at least 75 per cent of the exercises presented):

a) Two lines are parallel if and only if a pair of alternate interior angles are congruent.

b) Two lines are parallel if and only if a pair of alternate exterior angles are congruent.

c) Two lines are parallel if and only if interior angles on the same side of the transversal are supplementary.

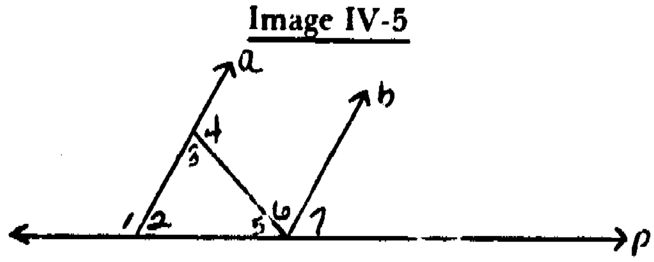
d) If two lines in a plane are parallel to a third line, then the two lines are parallel to each other.

Assessment Items

Look at Image IV-5 and the given information. Complete the following:

$M\measuredangle 1 =$
$M\measuredangle 4 =$
$M\measuredangle 5 =$
$M\measuredangle 6 =$
$M\measuredangle 7 =$

Image IV-5



a || b
$m\measuredangle 2 = 80$
$m\measuredangle 3 = 55$

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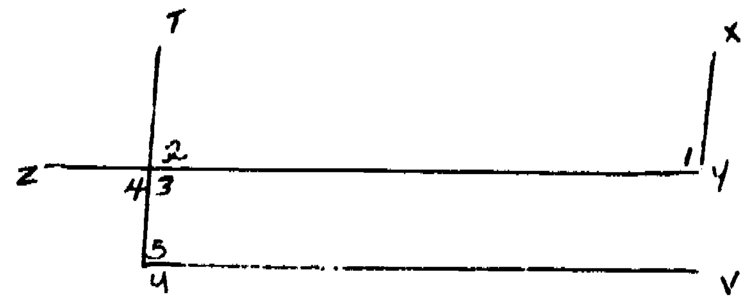
Look at Image IV-5A and the given information. Complete the following proof:

Statements	Reasons
1. $\overline{ZY} \parallel \overline{UV}$ $\measuredangle 1$ Supp. to $\measuredangle 5$	1.
2. $\measuredangle 3$ Supp. to $\measuredangle 5$	2.
3. $\measuredangle 1 \cong \measuredangle 3$	3.
4. $\overline{XY} \parallel \overline{TU}$	4.

Image IV-5A



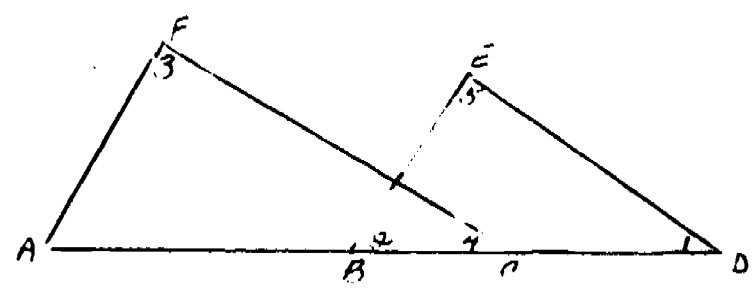
Given: $\overline{ZY} \parallel \overline{UV}$, $\measuredangle 1$ supp to $\measuredangle 5$
To Prove: $\overline{XY} \parallel \overline{TU}$

Alternate Assessment Items

Look at Image IV-5B and the given information. Complete the following:

M$\measuredangle$1 =
M$\measuredangle$2 =
M$\measuredangle$3 =
M$\measuredangle$4 =
M$\measuredangle$5 =

Image IV-5B



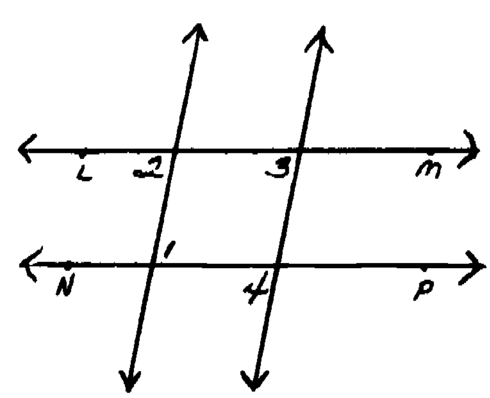
$\overline{AF} \parallel \overline{BE}$
$\overline{ED} \parallel \overline{FC}$
$\overline{FC} \perp \overline{BE}$

m$\measuredangle$FAB = 60
m$\measuredangle$FCD = 150

Look at Image IV-5C and the given information. Complete the following proof:

Statements	Reasons
1. $\measuredangle 1 \cong \measuredangle 2$	1.
2. $\overleftrightarrow{LM} \parallel \overleftrightarrow{NP}$	2.
3. $\measuredangle \quad \cong \measuredangle$	3.

Image IV-5C



Given: $\measuredangle 1 \parallel \measuredangle 2$
To Prove: $\measuredangle 3 \cong \measuredangle 4$

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Objective 6

Apply the following rules for lines:

a) In a plane, if two lines are perpendicular to a third line, then they are parallel to each other.

b) In a plane, if a line is perpendicular to one of two parallel lines, then it is perpendicular to the other line also.

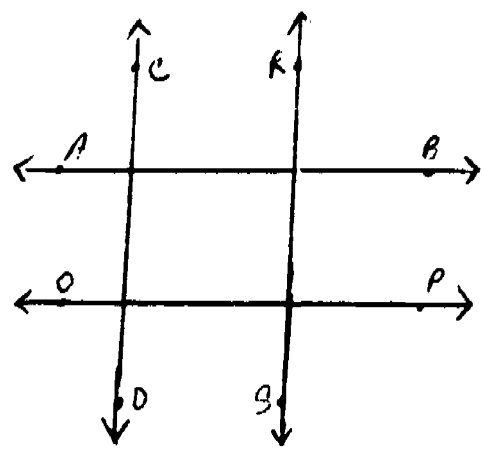
c) Through a point outside a line, there is exactly one perpendicular to that line.

Assessment Items

Look at Image IV-6 and the given information. Complete the following proof:

Statements	Reasons
1. $\overleftrightarrow{AB} \perp \overleftrightarrow{CD}$, $\overleftrightarrow{RS} \perp \overleftrightarrow{AB}$, $\overleftrightarrow{CD} \perp \overleftrightarrow{OP}$	1.
2. CD ∥ RS	2.
3. OP ⊥ RS	3.

Image IV-6



Given: $\overleftrightarrow{AB} \perp \overleftrightarrow{CD}$, $\overleftrightarrow{RS} \perp \overleftrightarrow{AB}$, $\overleftrightarrow{CD} \perp \overleftrightarrow{OP}$
To Prove: $\overleftrightarrow{OP} \perp \overleftrightarrow{RS}$

Write the letters of the true statements below

a) There is only one perpendicular to a line from a point outside a line.

b) In a plane, through a point outside a line, there is exactly one line parallel to the given line.

c) There is exactly one line skew to a given line from a point ouside the line.

d) If two lines are ∥, then they are ⊥.

Alternate Assessment Items

Given: line A ⊥ line L
line M intersects line L at X
X does not belong to line A

Which statement justifies the conclusion that line A cannot be ⊥ to line M?

a) In a plane, if two lines are $\perp$ to a third line, then they are parallel to each other.

b) In a plane, if a line is $\perp$ to one of two parallel lines, then it is $\perp$ to the other line also.

c) Through a point outside a line, there is exactly one $\perp$ to that line.

d) None of the above.

Objective 7

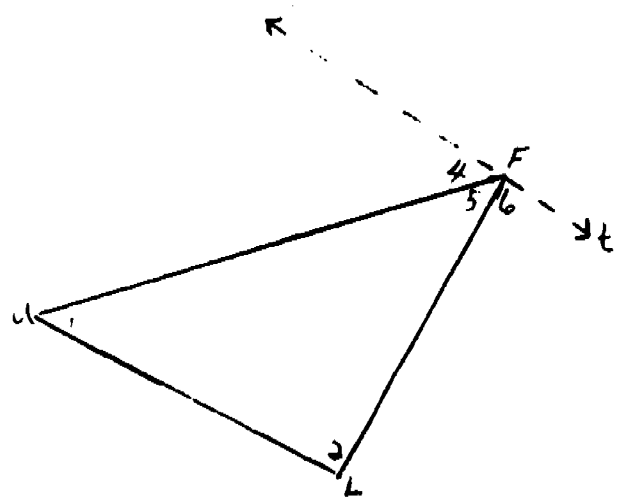
Construct the proof of the theorem: The sum of the measures of the angles of a triangle is 180.

Assessment Items

In the following proof, fill in the missing spaces. Refer to Image IV-7.

Statements	Reasons
1. ΔFLU; Int. $\measuredangle$'s 1, 5 & 2	1.
2. Construct thru F line T $\parallel$ to UL	2.
3. $M\measuredangle 4+M\measuredangle 5+M\measuredangle 6=180$	3.
4. $\measuredangle 4$ & $\measuredangle 1$; $\measuredangle 6$ & $\measuredangle 2$ are alt. int. $\measuredangle$'s	4.
5. $M\measuredangle 4 = M\measuredangle 1$ $M\measuredangle 6 = M\measuredangle$	5.
6. $M\measuredangle 1+M\measuredangle 5+M\measuredangle 2=180$	6.

Image IV-7



Given: ΔFLU, int$\measuredangle$s 1, 5 and 2
Prove: $m\measuredangle 1+m\measuredangle 5+m\measuredangle 2=180$

For further information relative to this course, see *Course of Study for Geometry*, Montgomery County Public School, Copyright, 1972, which documents all aspects of the regular noncomputerized course as used in the county schools.

Revisions to coded units have occurred on a day-to-day or biweekly bases and have been primarily related to criterion test item formatting and the acceptance of additional alternate correct answers. Two projects related to more extensive revisions have been completed.

The first project dealt with test item strategy. Geometry teachers using the CMI program were concerned about the situation of a student failing a criterion test item. When this situation occurred,

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the teacher received only a proctor message indicating which student had failed an identified objective in a particular unit. Their concern was that of knowing not only more about the content of the question failed but also they wished to know the answer the student had entered. It was felt this would enable the teachers to diagnosis explicit difficulties more adequately.

A revision in strategy was pilot tested when a summer school geometry class (1972) took the following form: When criteria for an assessment item was not met, the question and student response remained on the CRT screen for immediate teacher evaluation. After such evaluation, the typing of a code word by the teacher (in an undetected section of the screen) allowed continuation. It was felt that the revision worked satisfactorily during the summer session; thus it became a permanent part of this program as of September, 1972.

Teacher-Assistant Edith Gallogly collects proctor messages from the typewriter terminal at Newport Junior High School.

The second project of major consequence dealt with the need for maintaining the first curriculum unit INTRODUCTION TO LOGIC. As of September, 1972, this unit had not been used for three consecutive sessions; and it became questionable whether a need did exist for such a unit in the CMI Geometry Program. Three secondary mathematics supporting teachers were assigned the analysis of this problem during the school year 1972-1973.

After extensive review and evaluation of Unit I, it was determined that a need did exist and that the unit should be changed. Objectives and assessment test items were rewritten. The objectives of Unit I as revised follow:

1. Identify a simple statement.
2. Identify the negation of a given statement.
3. Identify a conjunction of two given statements.
4. Identify a disjunction of two given statements.
5. Identify an implication.
6. Identify the converse, inverse, and contrapositive of a given implication.
7. Identify a biconditional when given specific statements.
8. Distinguish among the symbols used to indicate a negation, conjunction, disjunction, implication, and biconditional.
9. Demonstrate the use of symbolic notation to indicate each of the following when given statements and the letters used to indicate these statements:

a) A negation

b) A conjunction

c) A disjunction

d) An implication and its converse, inverse, and contrapositive

e) A biconditional

10. Distinguish among the rules for determining the truth values of a negation, conjunction, disjunction, implication, and biconditional.

11. Construct the truth tables for a negation, conjunction, disjunction, implication, and biconditional.

12. Apply the rules for determining the truth values of statements which are negations, conjunctions, disjunctions, implications, and biconditionals when given two simple statements whose individual truth values can be determined.

13. Identify statements which are equivalent.

14. Demonstrate, by use of truth tables, that an implication and its contrapositive are equivalent statements and also that the converse and inverse of a given implication are equivalent statements.

15. Construct, in symbolic form, statements which are combinations of negations, conjunctions, disjunctions, implications, and/or biconditionals.

16. Apply the rules to determine the truth value of statements which are combinations of negations, conjunctions, disjunctions, implications, and/or biconditionals.

17. Construct a truth table when given a statement in symbolic form which is a combination of negations, conjunctions, disjunctions, implications, and/or biconditionals.

18. Determine, by constructing a truth table, if a given argument is a tautology.

Algebra Two – Final Examination

An analysis of problems given on previous examinations by the Einstein High School Mathematics Department revealed the need for further resources. As a result, six Algebra II teachers worked two months, part-time, for a total of 70 hours preparing the problems for this test. The design team examined several standardized algebra tests, curriculum guides, and courses of study in order to determine specific guidelines for test content. Twenty-five types of problems were identified as measures of Algebra II concepts, and four problems of each type were created. This bank of 100 problems provided the nucleus from which the test was generated. After the first year's use, an analysis of data was made and revisions written to assure that each of the four items were at approximately the same level of difficulty. The objectives follow:

1. Given a coordinate grid on which four lines are graphed and a linear equation, the student identifies* the graph of the equation.

2. Given a graph of a line with at least two points labeled or two points and four equations, the student identifies the equation of the line which contains the two points.

3. Given an equation of a line, the student identifies the slope of the line perpendicular to the given line.

4. Given a range and domain, the student identifies the corresponding function.

5. Given a proportion involving direct variation and two elements, the student identifies the solution of a similar proportion when the value of one element is changed and the value of the other element is unknown.

6. Given a function in the form of an equation, the student identifies the value of the function for a particular number.

7. Given four relations, the student identifies the one which is not a function.

8. Given a function in the form of an equation, the student identifies the value of the variable which will set the function equal to zero.

9. Given a quadratic equation of the form $ax^2 + bx + c = 0$ $(a, b, c \neq 0)$ or a graph representing the same, the student identifies its graph as a parabola.

10. Given an equation of a parabola, the student identifies the coordinates of its vertex.

11. Given a quadratic equation which has irrational roots, the student identifies the roots.

12. Given four equations, one of which does not have real roots, the student identifies that equation.

13. Given two linear equations in the form $ax + by = c$, the student identifies the solution set for the system.

14. Given two linear equations, the student identifies the number of ordered pairs of real numbers contained in the solution set.

15. Given a word problem dealing with values and number of coins, the student identifies the system of equations that could be used to determine the solution.

16. Given an integer raised to a negative fractional power, the student identifies its simplest form.

---

*Identifies is used exclusively to indicate that all responses to questions are in the multiple-choice form and that within the alternatives is included the one (and only one) correct answer.

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17. Given a number less than 1.00, the student identifies its scientific notational representation.

18. Given an expression containing positive, negative, and zero exponents and involving the operations of multiplication and division, the student identifies an equivalent expression with only positive exponents.

19. Given an expression containing the product of a variable raised to a positive integral power and a variable as a radicand raised to a power dissimilar to its index, the student identifies an equivalent expression written with a rational exponent.

20. Given a radical expression, the student identifies the simplest radical form.

21. Given an equation containing a radical (index of only 2) with a binomial radicand, the student identifies the solutions to the equation.

22. Given an equation in logarithmic form in which the logarithm is represented by a variable, the student identifies its value.

23. Given two logarithmic equations in the form of log X = constant, the student identifies the constant when the log product is formed.

24. Given the logs of two sequential numbers from a four-place log table, the student identifies the log of a number whose digits lie between the two numbers given.

25. Given an equation in logarithmic form in which the exponent is represented by a variable, the student identifies its value.

The testing strategy, scoring procedures, and evaluation techniques were developed by the staff of the CAI Program. For each type of problem, the computer randomly selected one of the four alternatives (4^{25} or 1,128,000,000,000,000 uniquely different tests could be created!). The registration procedure identified students by name, teacher, and period number. At the end of testing, the student, as well as the teacher, received a message indicating the number of problems answered correctly. Each teacher received an additional performance printout. At the end of the testing session, this evaluation, designed to ease the assignment of grades, ranked the students in each class from the highest score to the lowest score. A composite performance listing also was provided, giving the number of students receiving each score and an analysis of the normal distribution.

The Algebra II final exam, given on the computer, consisted of twenty-five problems presented randomly from a total of 100 test items.

Approximately 33 hours were required to code this examination for computer usage, with an additional eight hours spent on design and strategy. The Algebra II examination was pilot tested during the spring of 1971 and became operational for the school years 1971-1974.

Several programs originally designed for secondary mathematics have not been utilized during the past two years. These programs were coded into the APL programming language,

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which requires a dedication of the computer system. With the amount of materials being offered on a daily bases in COURSEWRITER II, APL programs cannot be offered. Thus the following programs may be considered not in use:

1. CAR OWNERSHIP

2. VOLUME/AREA INVESTIGATION

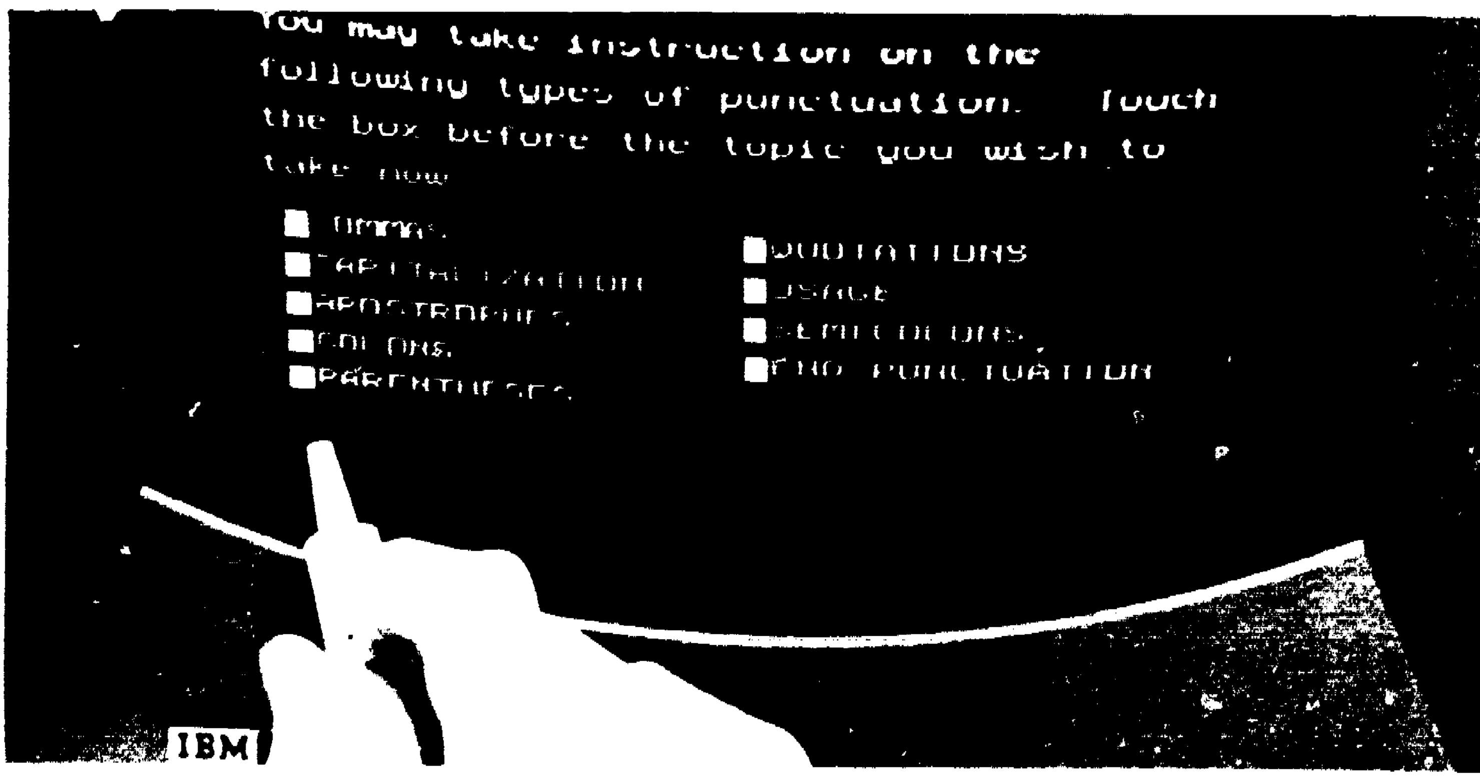
3. PERIMETER/AREA INVESTIGATION

2. English

The University of Texas, in cooperation with the McGraw-Hill Book Company, developed a freshman English program on eight areas of punctuation. This commercially packaged program PUNCTUATION is essentially an adaptation of the programmed textbook *English Review Manual* by James A. Gowen. It was the object of a research evaluation conducted in the spring of 1971 with seniors at the program high school. The results of that study are included in the Research Division of this report. (For a description of this study, see pages 457-458 of the *Title III Final Report*.)

During the fall of 1972, two high school English teachers used selected segments of the PUNCTUATION program with their eleventh and twelfth grade students in tutorial or drill and practice sessions. Eight punctuation segments in addition to 25 "help sections" in usage make up the complete package of PUNCTUATION. Based upon teacher decision to correlate ongoing writing assignments and punctuation drills, students could choose to work on any one of the following punctuation segments:

Commas	Apostrophe	Quotations
Semicolons	Parentheses	End punctuation
Capitalization	Colons	Usage



PUNCTUATION allows the student to receive diagnosis and tutorial assistance in eight different areas of punctuation.

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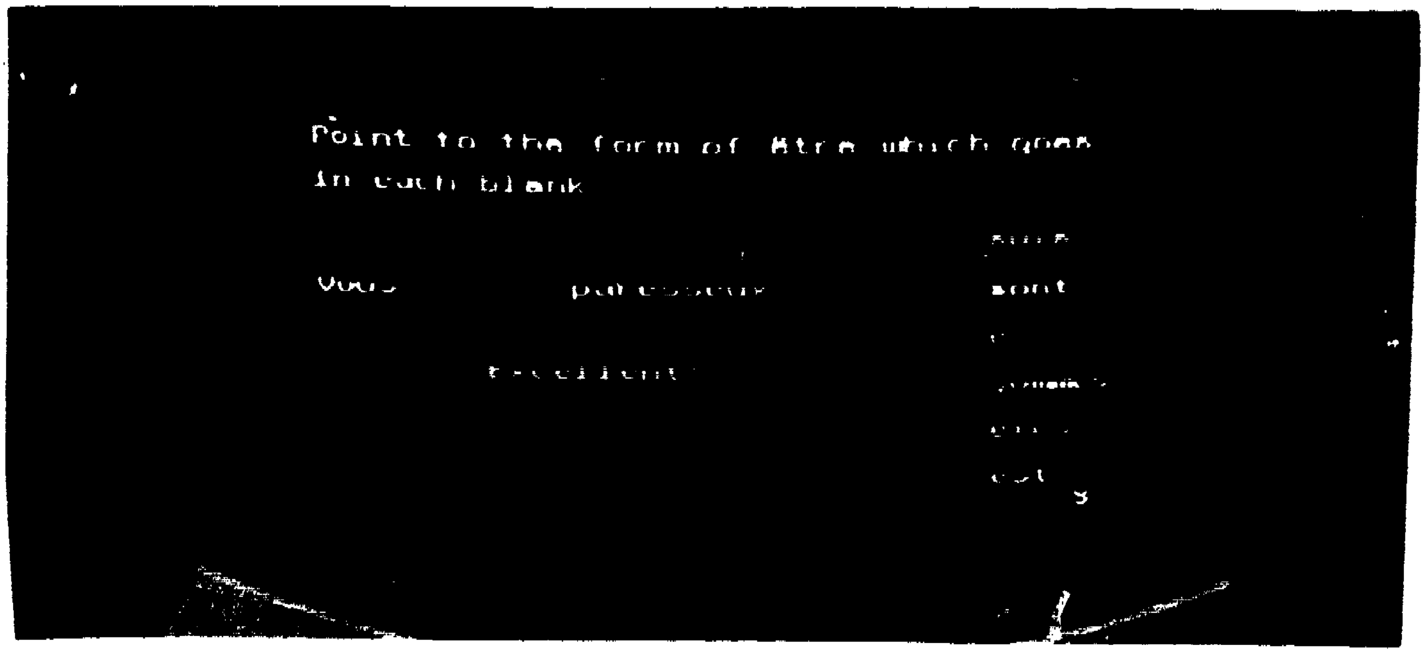
The program also was used with a tenth grade Advanced Placement English class at Einstein High School during March and April, 1973. Since many of the involved students had no previous on-line experience, it was necessary to provide orientation for operating the student terminal as well as orientation on how to use the program, which relies heavily upon the light pen. Initial instructions were given by the classroom teacher; later, eight students came to the terminal room where four students signed on while the remaining four observed. Each student was provided 25 minutes of computer time and then rotated his student station with the four observers This process allowed the entire class of 31 to complete designated sections of the program including commas, semicolons, capitalization, and parentheses. Several students chose "help sections" which are accessible at given intervals in the package. Some of the "help sections" frequently used were verbals, appositives, parallelism, and clauses, both adjectival and adverbial.

3. French

PASSÉ COMPOSÉ OF CERTAIN VERBS CONJUGATED WITH *ÊTRE* is a MCPS-developed package which was designed in the summer of 1969 but had never been used with students. This tutorial package was pilot tested in the spring of 1971 with 42 French II students a Albert Einstein High School and found appropriate as remediation for French I, II, and III. Since the study of verbs occupies an integral part of the French curriculum, the student must master these tenses before advancing in the language. Many students, it was discovered, encounter difficulty using the *passé composé* when it is initially introduced early in French I. Frequently this "troublesome" verb generates frustration for the French student throughout his study of the language. Thus the terminal objective of the program was stated as follows:

> "Given the subject of a sentence and the infinitive of a verb which requires a form of *être* in the past tense and which requires the correct agreement in gender and number, the student will construct the verb form."



Limited revisions were made in the French program *PASSÉ COMPOSÉ* by substituting French reinforcement words for English translations. Since a student's participation in this program depended upon his score on the pretest, a score box was added at the end of the pretest to inform both the student and teacher of his performance.

Three French III classes at Albert Einstein High School participated in the validation study in the fall of 1972. A total of 82 students from the three classes were assigned student numbers and pretested. The predetermined criteria stated that any student answering fewer than five out of six sentences correctly would enter the program. Eighteen students met the pretest criteria for elimination; 64 students failed the pretest and took the program. All 64 students finished the 82-minute program and also the posttest. These results are shown below:

Pretest mean = 34.71%

Posttest mean = 92.14%

d.f. = 57

Correlated $t = 15.98$, $p < .01$

Eighty-four per cent of the students answered at least 88 per cent correctly, or 95 per cent of the students answered at least 77 per cent correctly. As a group, the gain from pretest scores to posttest scores was significant at the .01 level of confidence.

The mean student use time was 81.80 minutes.

It can be concluded, therefore, that this program is valid at the French III level. Although the concept is initially taught in French I, it is interesting to notice that of the 82 French III students who took the pretest, 64 needed further instruction on *passé composé*. Furthermore, this concept, it can be said, was effectively taught by the CAI method whereas traditional methods had been less successful. The involved teacher and students were enthusiastic users and appeared to enjoy the individualization and privacy provided by the CAI technique. To follow up the results of the achievements, a retention study was conducted three months later. Fifty-eight students participated in this testing which is shown below:

Retention mean = 78.29%

Pretest mean = 34.71%

Posttest mean = 92.14%

Discussion: Although the losses of the students from the time of posttest to the time of retention were significant ($t = 3.69$, $p < .01$), the gains from the time of pretest remain substantive (gain of 43.58%, $t = 11.46$, $p < .01$).

4. Social Studies

As documented in the *Title III Final Report*, two social studies modules, FULLY AUTOMATIC REAL-TIME COMPUTER ELECTION (FARCE) and LATITUDE AND LONGITUDE, were considered developmental. During the school year 1971-1972, the social studies design team activities resumed under the direction of Thomas E. Robinson and Beverly J. Sangston.

FULLY AUTOMATIC REAL-TIME COMPUTER ELECTION, a political simulation written in the APL computer programming language, had been previously coded. The revisions conducted by the design team members consisted of author-debugging the original program and the writing of an off-line introduction for the students. A pilot study was conducted during the spring of 1972 with three classes of twelfth grade students in a *Problems of the Twentieth Century* course of study.

LATITUDE AND LONGITUDE is a tutorial program written for seventh grade geography students and coded into COURSEWRITER II. During the 1971-1972 school year, major revisions of strategy and content updating occurred. Revised criterion test items were written and recoding initiated. The program was later pilot tested from December, 1972, to January, 1973, with seventh grade students at Newport Junior High School. At the completion of this activity, it was felt that additional revisions to the curriculum were needed before further student use could occur.

5. Industrial Arts

The two mechanical drawing programs, scheduled for validation during 1971-1973, were revised by the author Don Konschnik. Both packages had been pilot tested with industrial arts students at Einstein High School in the fall of 1970, but neither had been validated. Therefore, in the spring of 1972, the author initiated validation procedures with 75 mechanical drawing students in Grades 10, 11, and 12 at Einstein High School. The validation study was not completed, however, although approximately 80 per cent of the first group finished the initial LIMIT DIMENSIONING package. Student use of the program did reveal some helpful data which indicated that specific revisions and adjustments should be made to the module. As a result, the on-line pretest was converted to a paper-pencil type test, allowing students to be tested in their classrooms. Students who lacked the entering behaviors for beginning the program could then be provided individual help by their teacher before proceeding to the computer terminals. Another step was taken to reduce the level of student frustration by reversing the order of pretest items from complex items first, to simple, and then to complex.

No revisions were made in the second mechanical drawing package, LIMIT DIMENSIONING OF MATING MACHINE PARTS.

6. Junior High School Orientation

With the installation of computer terminals in Newport Junior High, Beverly Sangston with the assistance of Donna Kirsch and Muriel Dahlberg, supporting teachers, developed an orientation package for incoming seventh grade students. The package was designed to include instruction on how to use the terminal and also how to open a combination lock. Three reading selections on school routines, rules, and extra-curricular activities were incorporated into the package accompanied by comprehension and vocabulary questions. Approximately 270 junior high students participated in the pilot testing of this program in the summer of 1972.

C. NON-MCPS MATERIALS

During the first three years, a number of curriculum packages which had been developed at other institutions were acquired by the CAI Program. Most of these were designed for use with college students and were not suitable in content and language for secondary pupils.

The criteria for selecting and using CAI materials in MCPS (described in the previous program document) requires that the instructional design include objectives, hierarchies, strategies, and validation procedures. Since the last publication, the following programs have been received:

Program	Source
ALGEBRA I (ALGEB)	Pittsburgh-Philadelphia-Penn State Consortium
GENERAL MATHEMATICS (GENMA)	Pittsburgh-Philadelphia-Penn State Consortium
MATHEMATICS DIAGNOSTIC SYSTEM (MDS)	National Technical Institute for the Deaf
EARLY IDENTIFICATION OF HANDICAPPED CHILDREN (CARE 1)	Pennsylvania State University
EARLY IDENTIFICATION OF HANDICAPPED CHILDREN (CARE 4)	Pennsylvania State University
IN-SERVICE MATHEMATICS EDUCATION (ELMATH)	Pennsylvania State University
ARMY BASIC ELECTRONICS COURSE (BASL)	U.S. Signal Center and School, Fort Monmouth

The philosophy of the CAI Program has been to support the individualization of instruction through the use of modular instructional packages which are usable on various grade levels and in many subject areas. Thus far no semester or year long courses have been used with MCPS elementary or secondary students.

The use of the Pittsburgh-Philadelphia Penn State Consortium in algebra (ALGEB) and general mathematics (GENMA), the University of Texas-McGraw-Hill punctuation program (PUNCT), and the Pennsylvania State University teacher training courses (CARE 1, CARE 4, ELMATH) are described in detail in the following sections. No other programs developed elsewhere are presently in use, although a number of students used the scientific notation and logarithms sections of the University of Texas Preskill's Package (PRESK) during the 1971-1972 school year.

Selected segments of two programs developed outside MCPS have been used at the program high school. ALGEB and GENMA were designed and developed at the Pennsylvania State University and later implemented at high schools in Philadelphia and Pittsburgh, Pennsylvania. Written for the IBM 1500 System, both programs are tutorially designed to cover an entire year's mathematics instruction.

ALGEB was designed to provide individualized instruction to students in the Algebra I curriculum. It consists of nine chapters:

I. Numbers and Set Notations

II. Properties of Equality and Operations

III. Integers: Properties and Operations

IV. Operations with Rational Numbers and Real Numbers

V. Equations, Inequalities, and Problem Solving

VI. Linear Systems

VII. Polynomials

VIII. Factoring Polynomials

IX. Rational Expressions

Selected Algebra I students used Chapters III, IV, and VIII as individual modular packages during the 1972, 1973, and 1974 school years; additional chapters were also utilized on an individual basis. GENMA, which was designed to provide individualized instruction to students in a general mathematics-type curriculum, consists of 11 chapters:

I. Equations

II. Negative Integers

III. Division of Whole Numbers

IV. Decimals

V. Fractions

VI. Ratio and Proportion

VII. Per Cent

VIII. Formulas

IX. Geometry

X. Measurement

XI. Graphing

Chapter V was used as a modular package by approximately 12 Math 10 students during the school year 1971-1972. Another 14 Algebra I students have used Chapter III for remedial purposes.

The Pennsylvania State University has developed several computer-assisted instruction courses for which continuing education or graduate credit is given. Three of these courses were made available to MCPS under agreements with the university. In place of university credit, MCPS teachers can obtain workshop credit approved by the State of Maryland Department of Education.

Computer-Assisted Remedial Education was made possible through grants from the Bureau of Education for the Handicapped and the Bureau of Educational Personnel Development, United States Office of Education, and The Penn State Foundation.

Early Identification of Handicapped Children (CARE I) was initially offered to Montgomery County teachers during the fall of 1971. The three-credit graduate course, developed by G. Phillip Cartwright and Carol A. Cartwright, was designed to provide teachers with the knowledge and skills necessary for the identification of handicapping conditions in children. It is a completely self-contained college-level computer-assisted instruction course that provides clinical sensitivity on the part of regular classroom teachers by helping them develop a diagnostic awareness and understanding of the strengths and weaknesses of handicapped and normal children. The course offers a unique opportunity for classroom teachers, using computer terminals with audio and image projector components, to learn the characteristics of exceptional children and to identify them. With specific knowledge and skills acquired in this course, teachers can recognize and refer children with handicapping conditions to experts for special help. Without this assistance, children might become educationally retarded by the age of nine or ten. Fifty-three Montgomery County teachers completed the CARE I course during 1971-1974.

A second in-service course also was offered to Montgomery County teachers during the spring of 1972. Elementary Math (ELMATH), also developed at The Pennsylvania State University, was first made available to Montgomery County teachers in February, 1972. Although this course was not as favorably received by participating teachers as CARE I, six elementary teachers completed the ELMATH course for in-service credit.

A third course, Education of Visually Handicapped Children, was developed by Marjorie E. Ward and Ralph L. Peabody at the Department of Special Education and Rehabilitation, University of Pittsburgh, in consortium with The Pennsylvania State University. This one-credit graduate course provides teachers with information about partially seeing and blind children as well as information on the process of seeing and the common causes of poor vision. Course participants are given opportunities to simulate classroom conditions and to vary the environment for a variety of student needs. The development of objectives, the selection of media and materials, and the design of instructional procedures are included in the course content. The first group of MCPS teachers to take CARE IV were enrolled in the 1973-1974 school year.

Research

Contributors:
SUSAN M. MORGAN
GRACE C. MULLEN
ROBERT POKRAS
THOMAS E. ROBINSON
BEVERLY J. SANGSTON

ERIC

II. RESEARCH

The CAI staff is continually seeking methods of improving the quality of computer-assisted instruction which it provides for students. In particular, it is concerned with how attitudes and achievement are affected by such variables as:

1. Grade level

2. Location of computer terminals

3. Amount of time spent on-line, and the way in which that computer time is scheduled

Increased attention also is being paid to maximizing the gains of low achievers. Thus each study is broken down so that the differential gains of high and low ability groups may be analyzed.

Validation studies-determining whether new programs teach what they purport to teach-are included elsewhere in this document. An effort has been made to include only those studies in this section using programs which have been validated but whose optimal use has not yet been determined.

A. 1971-1972 RESEARCH

During 1971-1972, research was undertaken in both the elementary and secondary schools using CAI as a part of their curriculum. An attempt was made to evaluate CAI not only in terms of achievement gains but also in terms of its efficiency, its differential affects on students with diverse ability levels, and its affect on classroom interactions. The year-long sixth grade study showed that these students made significantly greater gains in arithmetic achievement than did their counterparts in traditional classrooms. In secondary school, it was possible through the addition of a CMI program to enlarge geometry classes with no drop in achievement. A study also was conducted with Algebra II students to determine if the CAI program was of more assistance to the high or low ability groups. Unfortunately, sporadic use of the terminals makes it impossible to report meaningful results from this study. Another study directed itself towards teacher activity in the classrooms with computer support. The results indicated that with this technology the teacher was able to spend more time with individual students. In addition, CAI was used successfully with special education students. Complete reports of these five studies follow.

1. Individual Attention in CAI Classrooms

Hill and Furst (1969) compared the role of the teacher in Computer-Assisted Instruction (CAI) classrooms with traditional classrooms. Two of their findings were that (1) CAI teachers spent significantly more time informing students about procedural matters than did control teachers and (2) no significant difference in the amount of individual attention given to students was found between the two classrooms.

Montgomery County Public Schools (MCPS), Maryland, has used computer terminals in a secondary mathematics classroom since 1969. The terminals and the computer programs were provided by the MCPS CAI Program. The role of the teachers and the amount of individual attention they could provide was thought not to be similar to the role of the CAI teachers in the Hill and Furst study. Therefore, a study was designed to determine the amount and kind of individual attention given by teachers in CAI classrooms as compared with teachers in traditional classrooms.

ERIC

The focus of the study stems from a view of attention as a generalized reinforcer. B. F. Skinner in *Science and Humanity* explains the importance of attention:

> The attention of other people is reinforcing because it is the necessary condition for other reinforcements from them . . . The attention of someone who is particularly likely to supply reinforcement—a parent, a teacher, or a loved one—is an especially good generalized reinforcer and sets up especially strong attention-getting behavior.

Definitions

Individual attention is defined in this study as a type of personal interaction in which the teacher directs his activity to one student. Because there are many types of individual attention in the classroom, a single definition will not serve to explain this behavior thoroughly. For instance, the effect of a teacher telling a student to sit down and be quiet differs greatly from that of the teacher's listening to the student's difficulty with a homework assignment. In addition, how much the teacher's attention is focused on the specific student depends on the number of people in the entire interaction, that is, within hearing range. There is a probability that the teacher, when asked a question by a specific student, will consider the entire listening group when answering. The answer may be more general if the entire class is listening or more specific if no one else is listening.

For the above reasons, two sets of distinctions were made when observing teacher-student interaction. First, what was the content of the communication? The four classifications were as follows:

1. Subject matter—in all cases this was mathematics

2. Procedure (computer)—student wanted to know how to type in an answer, etc.

3. Procedure (other)—homework assignments, test dates, etc.

4. Other—weather, sports, etc.

The second distinction concerns the listening group. Three non-mutually exclusive definitions were formulated as follows:

> Definition I: The teacher is talking to one student with no one else listening, or the teacher is listening to one student.
>
> Definition II: Definition I or the teacher is talking to one student within a group of six students or less.
>
> Definition III: Definition II or the teacher is talking to one student within a group of seven or more students.

It is worth noting that each definition becomes wider in scope. Definition I is a subset of Definition II, which is a subset of Definition III.

Small group is defined as two to six students.

A CAI classroom is one in which the student uses the computer terminal for some part of his regular instruction or testing. In every case, the use of CAI has enabled the course to be entirely individualized. A conventional classroom is one in which CAI is not used in any form. In our control sample, the classess were taught in a traditional manner with some, but not extensive, individualization.

Method

The observations were taken at ten randomly predetermined times during the classroom hour. Classess meeting during the same period had the same observation times. The classess were observed every day for a week on alternate weeks. The study ran from February 28, 1972, to May 12, 1972, for a total of 12 weeks, 6 weeks when observations were scheduled and 6 weeks when no observations were scheduled. Any observation time which was missed because of special assemblies, fire drills, or substitute teachers was made up during the same time period on the next nonscheduled observation week. An exception was made for March 30, 1972, which was a holiday for all classes and was not made up the following week. The total number of observations for each of the experimental and control groups was 870.

For a preliminary study of two weeks' duration, four observers were trained; and following the training, they practiced on a number of pre-experiment trials. The inter-rater percentage of agreement was 87 on all items and 100 on items affecting any of the three definitions of individual attention. The six observers for this study were trained in the same manner.

The observation sheet was objective. The observer had to determine at the preselected time whether the teacher was listening or talking, the number of students listening if the teacher were talking, and the general content of the communication. There also were categories of Not in Classroom and Not Listening or Talking. See Table 1.

TABLE 1
Observation Sheet

Teacher Activity	______
Talking	______
to a specific student	______
rest of class listening	______
small group listening	______
no one else listening	______
to entire class	______
to small group	______
Listening	______
Content:	______
mathematics	______
procedure (computer)	______
procedure (other)	______
other	______
Not in classroom	______
Not listening or talking	______
	______

Sample

Three CAI classes at the experimental school and three control classes at another school were chosen. The schools were matched for verbal and nonverbal aptitude, achievement scores in reading and mathematics, size, and socioeconomic factors. The classes were matched for subject, time of day, ability level of students, and general characteristics of the teacher, such as experience, sex, and recommendation of department head. The participating teachers were told the study concerned student responses. They also were informed thoroughly about the procedural details.

Results

The mean percentages of teacher time spent giving individual attention are summarized in Table 2. Comparison of Definition III shows that CAI teachers gave individual attention significantly more time than control teachers. [$X^2 = 33.12$ (corrected for continuity) df = 1, $p < .01$].

TABLE 2
Individual Attention
Mean Percentage of Total Class Time

Definition	C.A.I.	Control
I	50%	26%
II	69%	30%
III	71%	44%

Chi square on Definition III:

$X^2 = 33.12$, $p < .01$

Table 3 shows the mean percentages of class time for all teacher activities. Chi squares were run for each category of activity, and the value of X^2 and the significance level of the comparison of the CAI teachers with the control teachers are found in the last column of Table 3.

TABLE 3
Summary of Teacher Activity
Percentage of Total Class Time

	Teacher Activity	CAI Class-room	Control Class-room	X^2 Comparison with CAI and Control (Corrected for Continuity) df = 1	Signif-icance
A.	Teacher talking to one student with no one else listening	41%	9%	143.06	$p < .01$
B.	Teacher talking to one student within a small group	19%	4%	64.85	$p < .01$
C.	Teacher talking to one student within the entire class	2%	14%	78.75	$p < .01$
D.	Teacher listening to one student	9%	17%	22.67	$p < .01$
E.	Teacher talking to the entire class	2%	39%	250.54	$p < .01$
F.	Teacher talking to a small group	8%	1%	52.48	$p < .01$
G.	Teacher not listening or talking to student(s)	19%	16%	1.74	n.s.
Total		100%	100%		

Table 4 summarizes the content area of teacher talk. There were no significant differences found in the content of teacher talk. However, it was found that control teachers talked more about mathematics when talking to the entire class than CAI teachers did [$X^2 = 191.05$, df = 1 (corrected for continuity), $p < .01$] while CAI teachers talked more about mathematics while giving some form of individual attention [$X^2 = 36.72$, df = 1 (corrected for continuity), $p < .01$].

TABLE 4
Content of Teacher Talk
Percentage of Total Classroom Talk

Teacher Activity	CAI Classroom	Control Classroom	X^2 Comparison with CAI and Control (Corrected for Continuity) df = 1	Significance
Talking About Mathematics	48.3%	53.6%	1.13	n.s.
Individual Attention	48.3%	30 %	36.72	$p < .01$
Entire Class	0 %	23.6%	191.05	$p < .01$
Talking About Procedure	8.9%	10.7%	2.48	n.s.

Discussion

Computer terminals in the classroom may be utilized in many ways. The CAI Program is dedicated to the use of the computer as a direct aid to the instructional process, allowing the teacher more freedom to attend to individual students when a specific need arises. It is felt that this creates an atmosphere rich in student-teacher interaction.

Although there was no difference in the total teacher time spent talking about mathematics, there was a difference in the teacher activity when discussing mathematics. In control classes, most of the discussions about mathematics was directed to the entire class, although some students already knew the material while others needed remedial help. This occurred in spite of the fact that some students already knew the material and others were not ready to learn the concept. In the CAI classes, most of the discussion about mathematics occurred during some form of individual attention. This situation lends itself to the student's specific needs. Theoretically, the individual attention is geared directly to the student's problem at the time he needs and wants help. This could result in higher achievement, and further studies to test this hypothesis are currently being planned.

Summary

Time-sampled observations of CAI and control classroom teachers yielded the following results:

1. CAI teachers gave significantly more individual attention to students.

2. No difference was found in the amount of teacher time spent discussing procedure or mathematics.

3. CAI teachers talked significantly more to one student with no one else listening.

4. CAI teachers talked significantly more to one student within a small group.

5. Control teachers talked significantly more to one student within the entire class.

6. Control teachers spent more time listening to one student.

7. Control teachers talked more about mathematics to the entire class.

8. CAI teachers talked more about mathematics when giving some form of individual attention.

9. No difference was found in the amount of teacher time spent not listening or talking.

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Hill, K. A., and Furst, N. F. "*A Comparison of the Role of Teachers in CAI Classrooms and Teachers in Traditional Classrooms*." Paper presented at the meeting of the American Educational Research Association, Los Angeles, February, 1969.

2. Assessment of An Individualized Computer Based Arithmetic Program

Educators have always stressed the importance of acquiring basic arithmetic skills in the elementary school. The procedure in traditional classrooms generally has been to teach a specific lesson followed by drill on related problems. Using this method of instruction and drill, classroom teachers have found it difficult to provide for individual differences.

Computer-assisted instruction (CAI), designed to diagnose, branch, drill, and instruct, assists the teacher in providing each student with his specific requirements at the optimum time. The program described in this study differed from many other CAI programs in several ways. In two of the three modules used, teacher instruction on specific skill and concept objectives was specified whenever a student's performance on the drill failed to meet the stated criteria. Instruction occurred before the student returned to the terminal. Therefore, a student needing concept building might not use the computer programs for several weeks. The third module was tutorial and a student was required to pass an on-line entering behavior test before using the program. Approximately 20 percent of the students completed all three modules while others were still on the first program at the end of the school year. In this study, which covered CAI use over an entire school year, each student was scheduled for one 30-minute session per week.

Studies comparing the use of CAI arithmetic drill and practice programs with traditional classroom methods have produced conflicting results. Weiner, *et al.*, (1969) showed that with ten-minute drills three times a week, over a five-month period, there were significant achievement gains in Grades 2, 3, and 5 in New York City Public Schools. However, a second-year evaluation study in the New York City Public Schools did not replicate Weiner's results (Abramson, *et al.*, 1970). Other short-term studies have shown significant achievement gains (Dawson and Norfleet, 1968, and Fejfar, 1969). No differences were found in a study involving two seventh grade remedial arithmetic groups, one using CAI drill and practice and the other, traditional methods (Crawford, 1970).

The purpose of this study was to determine whether significant gains in achievement could be made by providing an individualized arithmetic program which utilized computer terminals for diagnostic, drill, and tutorial purposes and which integrated their use into the regular instructional process.

Method

Subjects

The participants were sixth grade students from two similar Montgomery County elementary schools, four classes from the experimental school and four from the control school. Fifty-eight matched pairs of students were determined primarily on pretest scores; however, past achievement in arithmetic skills and problem solving as determined by the *Iowa Test of Basic Skills* was also considered. In addition, the schools were matched for academic and socioeconomic factors. The teachers involved had similar educational credentials and experience.

The sixth grade arithmetic program in both schools was prescribed by the Montgomery County Public Schools (MCPS) course of study *Elementary Mathematics*. In the skill areas, whole numbers and fractions were reviewed and remediation, where necessary, was provided. Initial and continuing instruction was given in decimals and per cents.

For the experimental subjects, arithmetic instruction was given in a heterogeneous grouping by classroom teachers. These students used the computer for diagnostic placement, prescribed drill, and instruction for approximately one-half hour a week. The time spent by each student at the terminal was part of, and not in addition to, his regularly scheduled time for arithmetic.

The control school was departmentalized in mathematics where the students received arithmetic instruction from one of two teachers. The grouping of the four mathematics classes involved in this study had been determined in September by each student's performance on a test of computational skills developed by Montgomery County Public Schools.

During the week of September 20, 1971, all subjects were pretested. Testing at the end of the school year occurred during the week of May 22, 1972. The standardized testing instrument was Part II of the *Cooperative School and College Ability Tests, Form 5A*, which was designed to measure the student's developed ability in the basic quantitative areas of whole numbers, fractions, and decimals. The 25 test items were multiple-choice in which the student selected an answer from among five choices. Students were allowed 20 minutes to complete the test.

A criterion referenced test, written at the CAI Program, was also administered. The 20-item test, requiring constructed responses, measured achievement on the terminal objectives of the three CAI modules. Only 53 matched pairs were used in the analysis of these test since five of the 116 students were absent on the second testing day.

Program

The CAI modules used in this program, OPERATION WHOLE NUMBER, SIGN-ON FRACTIONS, and LEARNING ABOUT PER CENTS, were developed at the Computer-Assisted Instruction Program, Montgomery County Public Schools, Maryland.

OPERATION WHOLE NUMBERS (OWN), VERSION II, written by Beverly J. Sangston, combines the CAI techniques of diagnostic testing and drill and practice in a program designed to build proficiency in the basic computational skills using whole numbers.

The student, following diagnosis, progresses through the program in a controlled sequence to attain the four terminal objectives:

1. Given an addition problem with three three-place numerals presented vertically, the student constructs the sum, regrouping in ones, tens, and hundreds place required.

2. Given a subtraction problem presented vertically, the student subtracts a three-place numeral from a four-place numeral, regrouping in hundreds, tens, and ones required.

3. Given a multiplication problem presented vertically in which one factor is a three-place numeral and the other factor is a two-place numeral, the student constructs the product.

4. Given a division problem with a four-place dividend and any two-place divisor, the student constructs the quotient and the remainder.

The content is divided into four units, one for each of the basic operations. Each unit within the program has the following components:

1. A pretest consisting of a survey test on the terminal objective.

2. A network of diagnostic tests to place the student at the appropriate level for drill or to prescribe instruction.

3. A sequence of drills to provide practice in a computational skill based on a specific concept.

4. A series of review tests in which problems from a designated drill sequence are randomly presented.

Each of these activities is controlled by a predetermined time element. The time allotted to complete each problem is based upon the difficulty index of the problem and the grade placement of the student.

At the completion of the four survey tests, the drill sequences, the review tests, or a combination thereof, the student is given a posttest. This test measures attainment of the terminal objectives.

SIGN-ON FRACTIONS (FRACT), also written by Beverly J. Sangston, is composed of 7 concept tests, 19 addition drills, and 20 subtraction drills. The terminal objectives of this segment are:

1. Given two fractions or two mixed numerals with unlike denominators, for which the lowest common denominator is not the denominator or the product of denominators, the student writes the sum in its simplest form. The whole numbers do not exceed 9, and the denominators of the fractions do not exceed 16.

2. Given two mixed numerals or a mixed numeral and a fraction with unlike denominators, for which the lowest common denominator is not the denominator or the product of denominators, the student writes the difference in its simplest form. The whole numbers do not exceed 9, and the denominators of the fractions do not exceed 16.

LEARNING ABOUT PER CENTS (LAP), written by Donna Kirsch, an MCPS teacher, is a complete CAI tutorial package. Entry into Part I of LAP requires knowledge of certain fractional concepts and skills. Part I has the following terminal objectives:

1. Given 10 common fractions having denominators that are either 2, 4, 5, 10, 20, 25, or 50, the student writes the per cent for each.

2. Given 10 integral per cents less than 100 per cent, the student writes a common fraction in lowest terms for each.

Part II requires the mastery of the terminal objectives in Part I and of certain entering decimal behaviors. Its terminal objectives are:

1. Given ten decimals less than one, written in tenths or hundredths, the student writes the per cent for each.

2. Given 10 integral per cents less than 100 per cent, the student writes the decimal for each.

Each experimental student was registered for the OWN program in September. If a student had not demonstrated mastery of the terminal objective on each operation in sequence, he was diagnosed on the enabling objectives for that operation and provided the related drill at the terminal or the necessary instruction by his teacher. Students reaching plateaus in one operation might be registered for diagnosis in the next operation upon teacher request. At any time during the year that a student finished the OWN program, and was recommended by his teacher, he could be registered for FRACT. Eleven students completed FRACT and were registered for LAP.

The CAI program was completely integrated into the regular classroom instruction. Students were informed about their progress continually and their teachers received the same messages printed by the computer. When instruction was prescribed, it was given to the student before he returned to the terminal.

Results

Standardized Testing

Scores on the standardized prettest and posttest for both groups are summarized in Table 1.

TABLE 1
Results of Standardized Test (SCAT)
N = 58

	CAI		Control	
Test	**Mean**	**S.D.**	**Mean**	**S.D.**
Pretest	**14.48**	**3.71**	**14.72**	**3.67**
Posttest	**19.67**	**3.28**	**18.26**	**3.10**

The pretest scores were not significantly different (t=1.00, df=57, n.s.). A t-test comparing the CAI gain scores with control gain scores showed that the CAI students made significantly greater gains in achievement than the control students (t=2.81, df=57, $p < .01$).

The results of the criterion referenced test are summarized in Table 2.

TABLE 2
Results of Criterion Referenced Test
N = 53

	CAI		Control	
Test	Mean	S.D.	Mean	S.D.
Pretest	5.59	2.95	5.07	1.91
Posttest	11.30	4.53	9.26	4.47

The scores of the two groups did not differ significantly on the pretest (t=1.20, df=52, n.s.). Comparison of the gain scores for both groups showed that the CAI group made a significantly greater mean gain than the control group (t=2.35, df=52, $p < .05$).

Discussion

The results of this study showed that the average gains of the two groups were significantly different on both the norm-referenced and the criterion-referenced tests. The experimental mean gains were significantly greater than the control mean gains.

The CAI programs in MCPS differed from those in the other studies cited. Of primary importance was the integration of all CAI use into the regular instructional process and the dependency upon teacher-student interaction. In addition, the study reflects the use of CAI over an entire school year. The time each student spent on CAI was approximately one-half hour per week and was part of the regular mathematics class time and not supplemental. Computer terminals had been used in the experimental school since September, 1969, lessening a possible "Hawthorne" effect.

The MCPS program depended upon a combination of the computer, the CAI modules, and student-teacher interaction. This study was not intended to discriminate between the effectiveness of the use of the computer for diagnosis, instruction, and drill and the CAI instructional segments themselves. The assumption has been made that the program would not be effective without the computer because the computer's capacity for branching, reinforcement, record-keeping, and assessment far surpasses any other system now available for regular classroom use.

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3. Evaluating The Effectiveness of A Computer-Managed Instructional System To Assist In The Individualization Of Geometry

During the summer of 1968, several Montgomery County mathematics teachers participating in a workshop, began developing behavioral objectives, hierarchies, reference materials, and criterion test items for a secondary school geometry course. The work continued through the following years until materials for the ten-unit course were completed in June, 1970. This course was designed so it could be used to individualize instruction in the regular classroom. However, the time necessary for teachers to evaluate criterion test items for each objective and provide the necessary feedback and direction for each student was prohibitive. In addition, all the instructional materials had to be duplicated and filed. Without an aide in the classroom, an excessive amount of teacher-time was spent on tasks other than instruction.

One of the objectives of the Computer-Assisted Instruction (CAI) Program was to assess the use of the computer for testing and test development. A decision was made to code the criterion test items for the first four units in geometry and pilot test their use in 1970 summer school. The trial use elicited such enthusiasm from both students and teacher that a computer-managed instruction geometry course was incorporated into the regular mathematics program for three classes during the school year 1970-1971. As the CAI Program was uncertain at that time as to future funding, no additional geometry units were coded until April of 1971. At that time the involved teachers decided that if the entire course were computer-managed, the instructor could handle larger class sizes. It was essential that if the classes were larger than normal, achievement must not be significantly different. This hypothesis was tested during the school year 1971-1972.

Method

Subjects

The participants were geometry students in one MCPS high school. Two classes with a total of 67 students were identified as the experimental group and three classes with 70 students as the control group. Students had been randomly assigned to the groups, and analysis of test scores measuring aptitude and achievement showed no significant differences between the two groups. Each of the three teachers had more than five years experience teaching secondary mathematics, and all of the classes were held during either fifth or sixth period of a six-period day. The Cooperative Mathematics Test — Geometry Form B (Part I)[1] was given as a pretest on September 7, 1971. The same instrument was administered as a posttest on June 2, 1972. "Part I may be given alone to survey the important outcomes of a typical high school geometry course."[2]

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[1] *Cooperative Mathematics Test — Geometry Manual*, Educational Testing Service, Princeton, New Jersey, 1962.
[2] *Ibid.*

Program

The experimental classes were completely individualized, utilizing the computer terminals for diagnosis and assessment. Each student in this computer-managed instruction (CMI) course followed this procedure:

1. Took an optional diagnostic test on the first unit
2. Given immediate feedback on achievement and prescription of entry level
3. Returned to classroom to study materials related to a cluster of objectives
4. Returned to the computer for a set of assessment tasks on the first objective in the cluster
5. Received assessment on each of the remaining objectives in the cluster upon successfully completing the initial objective
6. Signed off and restudied material in any way and at any point criteria was not met
7. Continued in same mode through each cluster in the unit
8. Took a test when all clusters in unit were completed
9. Repeated Steps 1-8 for each succeeding unit

The control groups were taught geometry by conventional methods

Results

Pretest scores for both groups, shown in Table 1, are not significantly different ($t = 1.15$, $df = 135$).

TABLE 1
Pretest Results of Standardized Test

	CMI N = 67		Control N = 70	
	Mean	S.D.	Mean	S.D.
Pretest	12.70	4.78	13.66	4.87

As the numbers of students who took the posttest on June 2, 1972, were much smaller than the original groups, an analysis of only those pretest scores was made ($t = 0.075$, $df = 81$, n.s.). Both the experimental and control groups made significant mean gains from pretest to posttest ($t = 13.63$, $df = 39$, $p < .005$; $t = 14.06$, $df = 42$, $p <,005$). The difference in mean gain scores between the two groups is not significant ($t = 1.23$, $df = 81$, n.s.). Scores on the standardized pretests and posttests are summarized in Table 2.

TABLE 2
Results of Standardized Test

Test	CMI N = 40 Mean	S.D.	Control N = 43 Mean	S.D.
Pretest	14.17	4.90	14.09	4.90
Posttest	24.95	5.72	26.33	5.61

Discussion

The experimental and control groups did not differ on pretest scores. Each group made significant mean gains between pretest and posttest, and these gains did not differ significantly. However, these groups did differ considerably in class size. The experimental classes averaged thirty-three students while the control classes averaged twenty-three. Thus, the geometry testing, diagnostic, and prescriptive course of study coordinated by a computer-managed system, provided an individualized program for a greater number of students per class with gains in achievement not different from the gains of traditional classes with smaller enrollments.

4. Algebra II Study

An Algebra II study was designed for the school year 1971-1972 to analyze those differences that CAI might make with high, average, and low achievers. One class at each ability level was to be taught in a traditional manner, while a second class of the same achievement level with the same teacher was to use available CAI modules integrated with their classwork. The available programs were on simplifying radicals, factoring polynomials, determining the slope of a line, and understanding as well as applying the concepts and skills of ratio and proportion, scientific notation, and logarithms.

A pretest was administered in September, a midterm in January, and a posttest in May. Pretesting showed no significant differences between CAI and control groups. Mid-year testing showed all groups making satisfactory progress with no significant differences between CAI and control groups. The same situation existed in May where mean gain by the total CAI Group was $\overline{X} = 11.5$ s.d. = 4.28 and for the total Control Group was $\overline{X} = 9.85$, s.d. = 4.55, t = 1.45, df = 75, not significant.

Further investigation showed that the CAI usage was limited at all ability levels, and no consistent patterns of terminal usage could be found. It was the opinion of the CAI staff that any differences in gain scores were due to other variables since the total time spent at the terminals by any group was too small to have affected achievement.

5. Special Education Study

In the spring of 1971, the Montgomery County Public Schools (MCPS) Computer-Assisted Instruction (CAI) Program instituted a project in cooperation with the administration and faculty of the county's only secondary school for the mentally retarded. A group of 14-16 students was transported to the CAI Program at Einstein High School one day each week where they were provided time at the computer terminals for arithmetic practice. Although these students participated for only a few weeks, they were enthusiastic users; and the involved staff members felt the experiences had been beneficial.

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The decision was made to provide the services for students from this school again in January, 1972. Classroom teachers identified ten students whom they felt would benefit most from participation. The school counselor, trained in the administration of standardized tests, gave each student an individualized test in arithmetic computation. The test used was the Arithmetic Section of the Wide Range Achievement Tests. Beginning on January 18, 1972, and ending on May 16, 1972, the students made the eight mile, 25-minute trip once a week to use the computer terminals, working on the CAI Arithmetic Program 40-50 minutes at each session. Late in May, 1972, the Arithmetic Section of the Wide Range Achievement Tests was administered again.

Students who used the computer terminals from the county's only high school for the mentally retarded showed significant gains in arithmetic scores. The computer's extensive capabilities serve as a precise judge as well as a tutor of each individual student, whatever the level of sophistication or remediation.

The CAI module used in this program, OPERATION WHOLE NUMBERS, was developed at the Computer-Assisted Instruction Program, Montgomery County Public Schools, Maryland. A description of the module follows with complete documentation available in the *Title III Final Report*, Project Reflect, 1969-1971.

OPERATION WHOLE NUMBERS (OWN), Version II, written by Beverly J. Sangston, combines the CAI techniques of diagnostic testing and drill and practice in a program designed to build proficiency in the basic computational skills using whole numbers.

The student, following diagnosis, progresses through the program in a controlled sequence to attain the four terminal objectives:

1. Given an addition problem with three three-place numerals presented vertically, the student constructs the sum, regrouping in ones, tens, and hundreds place required.

2. Given a subtraction problem presented vertically, the student subtracts a three-place numeral from a four-place numeral, regrouping in hundreds, tens, and ones required.

3. Given a multiplication problem presented vertically in which one factor is a three-place numeral and the other factor is a two-place numeral, the student constructs the product.

4. Given a division problem with a four-place dividend and any two-place divisor, the student constructs the quotient and the remainder.

The content is divided into four units, one for each of the basic operations. Each unit within the program has the following components:

1. A pretest consisting of a survey test on the terminal objective.

2. A network of diagnostic tests to place the student at the appropriate level for drill or to prescribe instruction.

3. A sequence of drills to provide practice in a computational skill based on a specific concept.

4. A series of review tests in which problems from a designated drill sequence are randomly presented.

Each of these activities is controlled by a predetermined time element. The time allotted to complete each problem is based upon the difficulty index of the problem and the grade placement of the student.

At the completion of the four survey tests, the drill sequences, the review tests, or a combination thereof, the student is given a posttest. This test measures attainment of the terminal objectives.

Each student was registered for the OWN program in January. If he did not demonstrate mastery of the terminal objective on each operation in sequence, he was diagnosed on the enabling objectives for that operation and either provided the related drill at the terminal or given the necessary instruction by his teacher. Students reaching plateaus in one operation might be registered for diagnosis in the next operation upon teacher request. Students were informed about their progress continually, and their teachers received the same messages printed by the computer. When instruction was prescribed, it was given to the student before he returned to the terminal. Only one student completed the four sections of the whole number program.

The pretest and posttest results are shown below:

Standardized Test Results
Grade Equivalents
N = 10

	Mean	S.D.
Pretest	4.15	1.04
Posttest	4.91	1.23
Gain	.76	.398

$t = 5.73, p < .01$ df = 9

Previous aptitude testing showed that the average IQ of these 10 students was 74. The range of IQ was 48 to 90. In spite of the low mean IQ, the gains from pretest to posttest were analyzed as though the students were normal (IQ = 100). The average gain score of the group was 7.6 months (SD = .398). Individual student gains ranged from 3 months to 1.7 years.

Students in special education, unique in many respects, require remediation and attention unlike that needed by other students. Maintenance of skills for mentally retarded high school age students is difficult, and an actual increase in scores is highly unusual. It is interesting to note, however, that in this study each student showed a gain in computational skills.

B. 1972-1973 RESEARCH

Comparative evaluations of the use of the arithmetic programs were planned for fifth and sixth grade students during the 1972-1973 school year. Unfortunately, in July, 1972, the computer and coaxial cables between the high school and the elementary school were accidentally servered; and as a consequence, the period between July, 1972, and February, 1973, was characterized by equipment malfunction. The fifth and sixth grade studies which were to be in process during this period are considered invalid. A fourth grade study commenced after cable repairs were satisfactorily completed in the middle of February.

During this school year, successful replication of the 1971-1972 study with special education students was carried out. A retention study on the sixth graders who used the terminals weekly in 1971-1972 showed the students had little achievement loss at the time of fall testing. In addition, a secondary school study was conducted with students using CAI units integrated into their Algebra I curriculum. Complete reports of these studies follow.

1. Individualized Computer Based Arithmetic Program Studies

Fourth Grade Study

To determine how to maximize student gains with the individualized Computer-Based Arithmetic Program, students used the terminals for different lengths of time during the 1972-1973 academic year. The fourth grades used the computer terminals once a week for only eleven weeks, averaging 5½ hours at the terminals during the second semester.

The experimental classes were matched on verbal IQ scores with comparable classes in another Montgomery County public school. The paired schools were also considerably comparable on socioeconomic factors.

The program used by the fourth graders was the CAI OPERATION WHOLE NUMBERS Program. The program involves diagnostic and drill and practice exercises in addition, subtraction, multiplication, and division. (For a complete description of the program, refer to the Computer-Assisted Instruction Project, *Title III Final Report*, 1972.)

The students in both groups were pretested February 14, 1973, on the Stanford Achievement Test, Intermediate I Computation. Scores of the two groups were essentially the same ($t = .53$, $p > .05$, $df = 148$).

TABLE 1
Results on Stanford Achievement
Intermediate I – Pretest

	N	Mean	S.D.
Experimental	69	15.65	5.69
Control	81	15.16	5.48

When the students were posttested June 4 on an alternate form of the Stanford Achievement Test, the scores of the experimental and control groups were no longer equivalent. There was no difference in gains between the high and low achievers when the students were divided into ability levels by their scores on the Stanford Achievement pretest.

TABLE 2
Mean Gains on Stanford Achievement Test Intermediate I

Experimental	High Achievers	5.0
	Low Achievers	5.7
Control	High Achievers	3.1
	Low Achievers	2.7

The experimental group showed a significantly greater gain than the control group ($F = 7.2, p < .01$).

TABLE 3
Source Table Anova on Posttest

Source	df	MS	F	
A-Groups	1	213.27	7.22	$p < .01$
B-Achievement Levels	1	0.73	0.02	n.s.
AxB	1	12.48	0.42	n.s.
Within Cell	137	29.52		

The Crandall Katousky I-E scale was given at the time of the posttest to determine whether the use of the computer terminal had developed more of a sense of self-responsibility among the fourth graders. Results showed there was no difference between the two groups on this test; hence the null hypothesis of no difference was accepted.

Apparently this small amount of time is helpful to the fourth graders in consolidating gains in whole numbers. Only four fourth graders completed the WHOLE NUMBERS PROGRAM.

Discussion

It is interesting to notice that this brief period at the terminals led to significantly greater gains for the CAI fourth graders. It may be that the fourth grade is the ideal time to begin such a drill program as the relationship of the regular classroom instruction in whole numbers consolidates the gains derived from the program. Also, students who need additional instruction and drill on prerequisite skills receive them before new, more difficult concepts are presented. Although the differences between the low and high achiever did not approach significance, it is notable that in the CAI group the low achieving group made greater gains than the high achieving group; while the reverse was true in the control group. When low achievers continue to make fewer gains in comparable periods of time, the gap between the groups widens so that by the sixth grade significant differences may exist between the two groups. Whereas, if the low achieving group can make greater gains with CAI, the gap between the groups can be decreased.

Sixth Grade Study

The sixth grade study was designed to test the effect of limited use of the computer terminals on math achievement scores. Sixth graders at Pleasant View Elementary School were to use the computer terminals on 12 separate occasions (about every 4 days) or an average of nearly 5 hours on-line time between September 11 and December 5. However, this use was sporadic because of cable difficulties. The students worked on both the WHOLE NUMBERS and the PER CENTS PROGRAM, but only 16 finished the WHOLE NUMBERS PROGRAM during the experimental period.

The students in the control school had been taught mathematics by the team teaching method during the experimental period. The sixth grades were comparable on county testing; but, unfortunately, there was no opportunity to pretest to see if, in fact, the two groups were equivalent. During the week of December 11, the three and one-half sixth grades at the control school (N = 98) and the three sixth grades at the experimental school (N = 83) were tested in arithmetic achievement. The SCAT Form 5A was given to test skills in whole number operations, fractions, and per cents. The whole number operations were also tested by the CAI staff-developed Criterion Referenced Test.

Results

No significant differences were found in the mathematics achievement scores on either of these instruments. A breakdown of the groups into four ability levels failed to show differences in the experimental and control groups at any of the four ability levels. Thus the null hypothesis of no differences could not be rejected.

TABLE 1

	Criterion Referenced		SCAT	
	Mean	S.D.	Mean	S.D.
Experimental	5.8	1.6	17.4	4.2
Control	5.6	1.7	17.4	4.8
	t = .68, n.s., df = 179		t = .07, n.s., df = 179	

Conclusions

It would be inappropriate to draw any grave conclusions from this study because of the recurrent terminal difficulties encountered by the students; however, it can be said that this short amount of time on-line appears insufficient to be of aid to sixth graders. The whole number skills are fairly well consolidated at this point, and there was not sufficient time for them to get into the higher level programs.

2. Retention Study

In the 1971-1972 sixth grade arithmetic study, the group which used computer-assisted instruction showed significantly greater gains on both norm-referenced and criterion referenced tests. These students had used the computer for diagnostic placement, prescribed drill, and tutorial instruction for approximately one-half hour each week during the school year.

To check on the transiency of these gains, a follow-up study was initiated in September of 1972.

Procedure

Fifty of the original 58 pairs were available and tested in county junior high schools in the fall of 1972. During the week of September 11, they were given the CAI Program-developed Criterion Referenced Test of 20 items. This test is in paper and pencil form; and students construct the answers to whole number, fraction, and per cent problems.

Results

The losses of the CAI and the control group over the summer were comparable.

	Mean	Standard Deviation	df = 49
Experimental	1.06	2.77	correlated t = .10 n.s.
Control	1.00	2.65	

Both groups of students retained significant gains from pretest (September, 1971) to retention test.

	Mean	Standard Deviation	df = 49
Experimental Pretest	5.82	2.93	$t = 8.53$
Retention	10.94	5.28	$p < .01$

	Mean	Standard Deviation	df = 49
Control Pretest	5.04	1.95	$t = 6.67$
Retention	8.14	4.15	$p < .01$

The gains of the CAI group remained significantly greater than those of the control group.

	Mean	Standard Deviation	df = 49
Experimental	5.12	4.21	$t = 3.25$
Control	3.16	3.24	$p < .01$

An additional comparison was made by examining the results of the Iowa Test of Basic Skills, Problem Solving Section. This test was administered to all seventh grade students throughout the county in October of 1972 (grade equivalent = 7.1). Forty-seven of the matched pairs took this test.

CAI Group	$\overline{X} = 7.52$
Control Group	$\overline{X} = 7.02$

$df = 46, t = 1.93, p < .10$

Discussion

The results of this study show that the experimental group was able to retain their superior gains over the summer period. In fact, in October, their problem solving skills averaged 4.2 months above grade level. These gains followed the use of the computer programs only once a week during their year as sixth graders.

3. CAI Increases Achievement for Special Education Students

The special education students who used the computer-assisted instruction arithmetic modules during the spring of 1972 demonstrated such notable achievement gains that the computer program was again made available for students from the same school during the 1972-1973 school year.

The purpose of this new study was to determine if the previous year's mentally retarded secondary students were an exceptional group or if the use of the CAI arithmetic diagnostic and drill program developed for the regular school would be of benefit to mentally retarded secondary students in general.

Procedure

Subjects

Eight students enrolled in a special public high school for the mentally retarded were identified by their classroom teachers to participate in this study. Their tested IQ's ranged from 48-85 with a mean of 71. Students were chosen because their teachers felt they could benefit from the computer program.

Method

The school counselor, who was trained in the administration of standardized tests, gave each student an individual test in arithmetic computation. The test used was the arithmetic section of the Wide Range Achievement Tests. Once a week, beginning on November 8, 1972, and ending in May, 1973, the students traveled 8 miles or 25 minutes to the computer terminals. They worked at the terminais 40-50 minutes at each session. Late in May, the arithmetic Section of the Wide Range Achievement Tests was given again.

Results

	Mathematics Achievement
Pretest Grade Equivalent	4.14
Posttest Grade Equivalent	5.38
Gain	1.24

$t = 4.33, p < .01$ $df = 7$

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Discussion

The expected gain for students of average IQ (IQ = 100) during this time period would be 0.7 of a year or 7 months. A gain of 1.24 years in 7 months (nearly twice the expected for an average student) is almost unheard of for a special education student. Maintenance of skills for these students is difficult, and an actual increase in scores is highly unusual. As in the previous study, every student who used the computer arithmetic showed a gain in mathematics achievement during the school year. Even if part of this achievement can be accounted for in terms of the extra attention and prestige of going to a regular high school, the gains from using the CAI arithmetic program are still remarkable.

4. Algebra I Study

Introduction

The Algebra I students at Einstein High School were taught by an individualized self-pacing curriculum in 1972-1973 rather than by the traditional classroom method. Some of the students received six CAI modular instructional packages as part of the self-pacing curriculum. The CAI packages dealt with the following concepts: factoring polynomials, slope of the line, operations with signed numbers, ratio and proportion, special products, and radical simplification. Two of the CAI packages used were developed by the Pennsylvania State University Consortium, College Park, Pennsylvania, while the others were developed by the CAI Program staff.

Procedure

Two of the five Algebra I classes at Einstein High School were designated as CAI and self-pacing experimental classes. Two additional classes were designated as self-pacing with no CAI support. Since 90-95 per cent of the students taking Algebra I are tenth graders, those students in the Algebra I classes who were eleventh or twelth graders were not considered. In addition to the control classes within Einstein, another county school was identified as a control school which had a comparable student population in terms of intelligence and socio-economic factors. The students at the control school were taught the same 12 curriculum units as the students at Einstein, but by the traditional lecture demonstration mode. Algebra I students in both schools were pretested on the Lankton First Year Algebra Test during the week of September 8, 1972, and posttested the week of June 14, 1973, on the same test. As well as looking at the total scores on the Lankton Algebra I Test, a separate analysis was done on the eight items specifically related to the six CAI modules.

The purpose of this study was: to determine if the individualized self-pacing Algebra I curriculum integrated with CAI affected achievement gains when compared with the individualized self-pacing Algebra I curriculum alone and the traditional lecture demonstration mode of instruction. In addition, the study sought to determine if there was a difference in achievement among the three groups on the test items related to the six concept areas taught by CAI.

Results

The students in the three groups who took both tests did not score significantly differently ($F = .04$, n.s.) on the pretest.

TABLE 1
Pretest

	Control School	Einstein Non-CAI	Einstein CAI
N at posttest	65	29	33
$\bar{X}$	17.0	17.07	16.67
Original N	140	75	54

TABLE 2
Total Test
Analysis of Variance – Pretest Scores

	SS	DF	MS	F
Between	3.20	2	1.60	.04 n.s.
Within	4993.2	124	40.27	
Total	4996.4	126		

All three groups made significant gains from the time of pretest to the time of posttest.

TABLE 3
Analysis of Gain – Pretest to Posttest (Total)

	Control School N = 65	Einstein High School Self-Pacing N = 29	Einstein High School CAI Self-Pacing N = 33
Pretest	m = 17.0 S.D. = 5.92	m = 17.07 S.D. = 6.65	m = 16.67 S.D. = 6.58
Posttest	m = 22.89 S.D. = 6.94	m = 25.03 S.D. = 3.59	m = 27.03 S.D. = 6.47
T-Score	t = 8.23 df = 64	t = 5.96 df = 28	t = 10.58 df = 32
Significance	p < .01	p < .01	p < .01

The pretest to posttest gain scores for the control, self-pacing, and CAI self-pacing groups did differ significantly ($F = 7.495; p < .01$).

TABLE 4
Analysis of Variance – Pretest to Posttest

	SS	DF	MS	F
Between	538.67	2	269.335	7.495 p < .01
Within	4455.83	124	35.9341	
Total	4994.5	126		

The CAI self-pacing group made the greatest gain from pretest to posttest (gain m = 10.36). The self-pacing group made a greater gain from pretest to posttest than did the control group (gain m = 7.96 vs. gain m = 5.89).

On the special items, the groups were not significantly different at time of pretest (F = .59, n.s.). But all three groups made significant gains from pretest to posttest.

TABLE 5
Analysis of Variance – Pretest Scores Special Items

	SS	DF	MS	F
Between	1.98	2	.99	.59 n.s.
Within	209.01	124	1.69	
Total	210.99	126		

TABLE 6
Analysis of Gain – Pretest to Posttest – Special Items

	Control School N = 65	Einstein High School Self-Pacing N = 29	Einstein High School CAI Self-Pacing N = 33
Pretest	m = 2.11 S.D. = 1.25	m = 1.79 S.D. = 1.09	m = 2.00 S.D. = 1.48
Posttest	m = 3 34 S.D. = 1.36	m = 3.76 S.D. = 1.91	m = 4.48 S.D. = 1.48
T-Score	t = 6.53 df = 64	t = 5.47 df = 28	t = 8.50 df = 32
Significance	p < .01	p < .01	p < .01

The pretest to posttest gain scores for the control, self-pacing, and CAI self-pacing groups did differ significantly ($F = 17.35$; $p < .01$).

TABLE 7
Analysis of Variance – Pretest to Posttest
Gain Scores – Special Items

	SS	DF	MS	F
Between	77.81	2	38.90	17.35 $p < .01$
Within	285.67	124	2.30	
Total	363.48	126		

The CAI self-pacing group made the greatest gain from pretest to posttest (gain m = 2.48). The self-pacing group made a greater gain from pretest to posttest than did the control group (gain m = 1.97 vs. gain m = 1.23).

Discussion

The conclusions drawn from this study must be made with some reservation due to the extremely high drop-out rate and the lack of hard data on teacher comparability in the three groups.

The gains made by the CAI group are considered to be sufficiently great to warrant further utilization of these modules.

5. **Student Attitudes Towards PUNCTUATION Program**

Overall Likert Rating = 3.7

1. Computer-Assisted Instruction created a challenge for me.
2. Use of Computer-Assisted Instruction was a waste of time.
3. I feel CAI material was presented in an interesting way.
4. CAI made learning too mechanical.
5. CAI permitted me to work in a relaxed atmosphere without the constant threat of failure.
6. I often felt as if the CAI Program was designed especially for me.
7. I felt many times that the computer was my private teacher.
8. The computer's overpowering knowledge caused me great frustration.
9. I found myself concentrating more on the way to operate the terminal than on understanding the course material.

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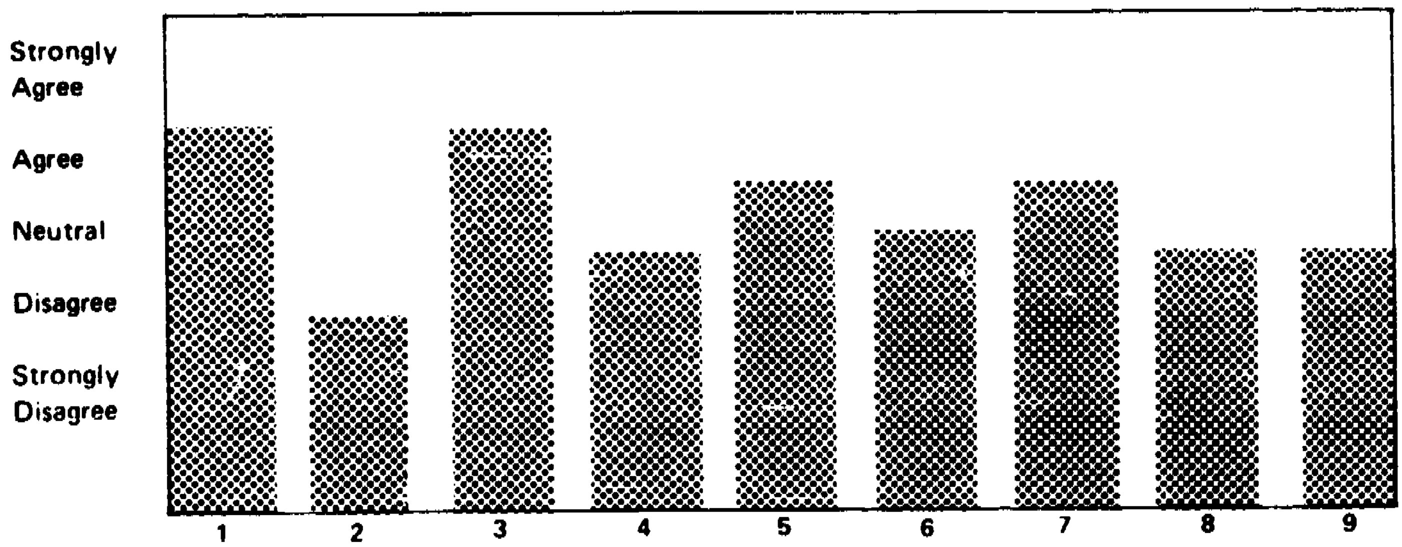

C. 1973-1974 RESEARCH

The recommendations relative to the extension of computer-assisted and computer-managed instruction as described in this document under Program Plans were made in the fall of 1973. Any research designs planned for the 1973-1974 school year would have been in process at the time when decisions would have to be made and recommendations approved.

Therefore, the 1973-1974 research was planned to investigate other factors as well as achievement which may influence the ways in which this technology is utilized.

With these objectives in mind, the staff planned two research projects: one at the fourth grade level and a second at the sixth grade level.

Fourth Grade Study

The Program Plans recommended that computer terminals be located in elementary school classrooms instead of in terminal rooms. The experience of placing terminals in a first grade classroom had been extremely satisfactory. As a consequence, a fourth grade study was planned to determine the feasibility of such an approach by the placement of one computer terminal in a single classroom. Student attitudes toward CAI were measured by a questionnaire which showed there were no significant differences between the students who went to the terminal room and those who had a terminal located within the classroom. Although both fourth grade groups using the terminals made significant achievement gains during the school year, one group had significantly higher scores on the pretest and no comparison of the groups could be made.

In view of this information, it was determined that terminals could be placed in classrooms, mathematics laboratories or in libraries rather than in terminal rooms. The classroom teachers would determine the use of the terminal at their discretion, thereby providing greater flexibility in scheduling students.

Sixth Grade Study

One research project at the sixth grade level was planned to determine if two one-half hour CAI periods each week either semester would be more beneficial than a single half-hour per week for the entire year. The students from one class were scheduled for the half-hour weekly sessions and those from the two other classes for two half-hour sessions for one semester. No significant differences in achievement were found when the concentration of usage in either semester was compared with utilization throughout the entire year in sixth grade. It would appear that it is the total hours of CAI exposure in the sixth grade that makes a significant difference in achievement. This fact may allow for greater flexibility in its use by teachers. Additional evaluations of various time schedules would need to be made at other grade levels to reach any definitive conclusions.

A second study was planned to replicate achievement gains seen with sixth graders using the OWN, FRACT and LAP programs.

At the beginning of the academic year, two schools were chosen as possible controls. These schools were matched in IQ and socio-economic backgrounds. The sixth grades in these schools were then given the Arithmetic Computation Subtest of the Stanford Achievement Test, Intermediate II. Through the IQ and socio-economic matching, the schools were expected to show equivalent performance on this math pretest. If these classes were then matched on IQ, socio-economic factors, and had equivalent math pretest scores, a statistical comparison would have been performed on gain scores at the end of the school year. But the groups were not equal on math pretest performance. The sixth grade classes, which were intended to be experimental classes, scored significantly higher on the Arithmetic Computation Test than did the control classes.

This difference on pretest performance should be examined more closely. It is of interest here to note several factors which might have affected performance on the pretest. A longitudinal study (Clyde Bohn, 1974) on the MCPS CAI project may shed some light here. The Bohn study found ". . . that the CAI group had greater gain" over the two-year period in mathematics achievement test scores. Although there are limitations on the strength of the conclusion of this study, the data are similar to the findings of the sixth grade pretests. Thirty-five per cent of the students in the experimental group had been in the CAI program for one year (in fifth grade), and fifty-two per cent had been in the CAI program for the two previous years (fourth and fifth grades). If the data used by Bohn are indicative of the longitudinal effect of CAI, then the pretest discrepancy found here may be due to the previous CAI classes to which these students were exposed.

Further evidence of the affects of CAI on the performance of elementary students in mathematics is evident in the per cent of students classified as "one or more years below grade level." On the basis of the Iowa Test of Basic Skills, the per cent of students below grade level by a year or more in the experimental school has dropped from approximately 29 per cent to 13 per cent. In the control schools, the per cent of students has continued to be about 26 per cent. These statistics indicate that computer-assisted instruction may be a factor here.

D. OUTSIDE RESEARCH

1. A Study of the Effectiveness of COMPUTER-ASSISTED INSTRUCTION Versus PROGRAMMED INSTRUCTION in the Teaching of Similar English Grammar and Punctuation Skills*

A research project evaluating the use of a Computer-Assisted Instruction approach to the teaching of English grammar and punctuation was initiated in Montgomery County, Maryland, in the fall of 1970. Seniors in the Albert Einstein High School were randomly assigned to one of three groups; each of the four teachers taught all three methods.

One group was assigned to the CAI Grammar and Punctuation Program (PUNCT). The second group was to use a programmed instruction text, entitled *English Review Manual: A Program for Self-Instruction,* on which PUNCT was based. The third group, the control group, would attend only regular English classes during the two-month period of the evaluation project.

The research was a pretest-posttest-control group design. The test administered was the STEP "Mechanics of Writing" test, Forms 2A and 2B. Classes in all treatment groups were randomly divided into two halves, each half to be administered a different form of the test as a pretest and the alternate form as the posttest. Data concerning the topics studied by the CAI and PI groups and the time spent studying were collected. In addition, cumulative grade point averages were collected for the students.

The implementation of the study began with the administration of the pretest on March 4, 1971, and concluded with the administration of the last posttest on May 19, 1971.

Analysis showed that students' mean ages were not significantly different among the three groups. Thus, students' data could be blocked into different age groups for analysis.

Analysis also showed that there were no significant differences among the three groups with respect to grade point averages, pretest scores, or posttest scores.

However, a highly significant difference was found between the means of the time spent on the grammar and punctuation material used by the CAI and PI groups during the eight-week period. The CAI students spent considerably more time in studying the same instructional topics than did the PI students. However, the CAI students worked in a branching program and had the option of covering far more material within the framework of each specific lesson. The PI students worked in a linear program and had more opportunities to omit sections of each lesson and even entire lessons. As both groups of students worked independently and had the option of terminating instruction at any time, the fact that the CAI students worked longer is significant. However, posttest scores indicated no differences in gains between the CAI and PI groups.

Further analyses were conducted within a factorial design in which data were grouped by factors in addition to treatment. The two factors considered were sex and age.

Analysis of covariance was used within the context of a 3 x 2 (treatment by sex) factorial design, first with grade point average as the covariate and then with the pretest as the covariate. In neither instance, in either main effects or interactions, were significant differences found.

*Reprinted by permission from Educational Developmental Laboratories, Inc., a Division of McGraw-Hill Book Company

With analysis of covariance in a 3 x 3 (treatment by age) factorial design with grade point average as the covariate, highly significant differences among the main effect, age, were found. *Post hoc* analysis showed that the low and average age groups scored significantly higher on the posttest than did the high age group.

However, when analysis of covariance was conducted within the same 3 x 3 factorial design, using the pretest as the covariate, no significant differences were found in main effects or their interaction.

Conclusions

Analysis of data in this study revealed the following information:

1. The mean ages of three treatment groups were not significantly different.

2. The cumulative grade point averages of the three treatment groups were not significantly different.

3. There were no significant differences on the scores of the pretest among the three treatment groups.

4. There were no significant differences on the scores of the posttest among the three treatment groups.

5. The CAI students spent significantly more time on their grammar and punctuation program than did the PI students.

6. No significant differences among the three treatment groups on the posttest were found when sex was factored out.

7. When age was factored out, using grade point average as the covariate, significant differences on the posttest in favor of the high and average groups were found.

8. When age was factored out, using the pretest as the covariate, no significant differences were found on the posttest.

2. A Comparative Study of Achievement in the Concepts of Fundamentals of Geometry Taught by Computer-Managed Individualized Behavioral Objective Instructional Units Versus Lecture-Demonstration Methods*

Purposes of Study

The purposes of this study were:

1. To identify and compare the effect on student achievement of a computer-managed geometry course utilizing individualized instructional modules built on behavioral objectives against traditional instructional methods

2. To identify how selected individual aptitudes interact with the presentation of a behaviorally oriented curriculum and whether these differ from traditional curriculum method

*Abstract of George Washington University Dissertation by Merrill E. Fisher

Methods and Procedures

This study was conducted during the 1971-1972 school year at Albert Einstein Senior High School, Montgomery County, Maryland. The sample was selected from among those eleventh grade students who elected geometry in their program of studies.

The Cooperative Mathematics Test for Geometry was used to assess academic achievement. In addition, scores from the Lorge-Thorndike Intelligence Tests, Tests of Academic Progress, and other selected variables were obtained from the pupils' academic records.

These data were analyzed on the IBM 360/Model 50 computer at the George Washington Computer Center. A variety of statistical techniques was utilized in analyzing the data. Included were the following: analysis of variance, chi-square, analysis of covariance, correlation matrices, multiple backward regression analysis, and multiple regression analysis.

Conclusions

The following conclusions are based on the findings of this study:

1. The computer-managed behavioral objective curriculum and the traditional curriculum are equally effective in developing the basic skills, concepts, and logical reasoning skills of geometry.

2. The computer-managed behavioral objective curriculum and the traditional curriculum are equally effective in producing measurable learning gains.

3. The correlations indicate that there is a direct relationship between achievement in geometry as measured by the Cooperative Mathematics Test and the L-T verbal and nonverbal scores. Based on the fairly high correlation between the Cooperative Mathematics Test score and the L-T nonverbal score, one must conclude that the Cooperative Mathematics Test is measuring the nonverbal, abstract spatial concepts involved in geometry. From the lower (but still significant) correlation between the Cooperative Mathematics Test scores and the L-T verbal scores, one must conclude that the Cooperative Mathematics Test is not measuring the geometric concepts using verbal symbols to the same extent it is measuring the nonverbal or that the verbal concepts are less important than the nonverbal concepts in high school geomety.

4. One must conclude from a comparison of the degree of correlation between the Cooperative Mathematics Test scores and L-T nonverbal scores and mathematics achievement scores that the traditional curriculum was slightly superior in teaching these concepts, while the computer-managed instruction curriculum was slightly superior in teaching the verbal concepts related to geometry. There is also a more direct relationship between the final geometry grades and achievement as measured by the Cooperative Mathematics Test for the students studying the traditional curriculum than for the students studying the computer-managed instruction curriculum.

5. The L-T nonverbal scores and the final grades assigned in Algebra II are significant (.05 level) variables for predicting success on the Cooperative Mathematics Test.

6. Students who study the computer-managed instruction curriculum are more likely to achieve at predicted levels of expectancy than students who study the traditional curriculum.

7. Average ability students are more likely to achieve at their predicted levels of expectancy by studying the computer-managed instruction curriculum, while high ability students are more likely to achieve at their predicted levels of expectancy by studying the traditional curriculum.

Recommendations

1. This study should be replicated for different types of school populations in order to determine if the results obtained in this design are typical or atypical.

2. This study should be replicated with an increased teacher-pupil ratio for the computer-managed instruction curriculum to determine if achievement gains are maintained with the added economic advantage.

3. Studies of a similar nature should be performed in other mathematics subjects to reveal the effectiveness of computer technological applications.

4. Expanded research efforts should be financed and carried out to determine the effectiveness of computer technological systems in public school settings.

Developmental Curricula

Contributors:
ALEX DUNN
THOMAS E. ROBINSON
BEVERLY J. SANGSTON
ANNE TIPTON

ERIC

III. DEVELOPMENTAL CURRICULA

A. ELEMENTARY

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The development of extensive CAI curriculum was not planned for 1971-1974. More than 40 modular instructional packages had been written during the program's initial phase under Title III funds (1968-1971) during which time most of these programs were validated. Emphasis has been given during 1971-1974 to the evaluation of this already-developed curriculum with the creation of a limited number of new modular instructional packages in selected areas.

One major innovative project being tested is a first grade computer-managed instructional system which is described in this section. Still other modules which were underway or being considered for development at the end of Title III were extended into the 1971-1974 phase. Some of these materials have been completed and are currently in operation; others are still in various stages of development. One area which will receive considerable attention in the near future is that of beginning reading. The rationale underlying the development of this area is also included in this section of the report.

The method of developing curriculum has continued the same as it was during the program's earlier phase. New packages are pilot-tested with students, debugged, and then validated with specific target populations to determine whether or not the package teaches what it purports to teach. This is a critical stage for any newly developed package, and the CAI Program has insisted upon using only validated curriculum. Finally packages are evaluated in terms of their usefulness and effectiveness to teach as compared to other modes of instruction. Results of those studies, both comparative and long-range, are included in this document. (See Research)

1. The First Grade Program

The emphasis of the CAI Program has been shifting gradually from a purely research and development effort in the computer-assisted instruction field to an operational program which would address itself directly to those instructional areas in which improvement in basic skills would be of the greatest benefit to the students in the school system. In view of this shift, it was decided that the monitoring of a sequential developmental program in reading, arithmetic, and language arts would be beneficial for primary children. The optimization of success for each child would in turn enhance his self-confidence and self-concept and aid in making him a more independent learner.

Activities in the classroom are varied and success-oriented. Here a small reading group discusses follow-up questions to the story they have just completed. In the background other students practice writing skills while two students work at the computer terminals.

The first grade represents the beginning of formal instruction in reading, language arts and arithmetic for most public school students. The need for using audio with this age student is obvious. The availability of the 1506 audio unit to be used in conjunction with the 1510 CRT prompted the CAI Program in the spring of 1972 to develop a computer-managed instructional

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program for one first grade class at Pleasant View Elementary School. The design for this computer-managed instructional system was developed and work was begun on the instructional objectives, assessment items, and strategies in the areas of reading, arithmetic, phonics, and language arts.

The goals of the management system were:

1. To determine if children in this age group could successfully interact with the computer terminal equipment. This involved listening with earphones, typing on the keyboard, and using the light pen

2. To increase achievement in reading and arithmetic

3. To develop beginning self-management skills

4. To aid the teacher in diagnosing each child's needs and in monitoring his progress on a daily basis

In August, 1972, two computer terminals with keyboard, light pen, and two audio units were installed in the classroom. The computer literacy mini-course, developed for kindergarten and first grade children, was used as an orientation package. It provided each child with the experiences of listening to a story, following audio instructions, and responding with the light pen upon computer request, each of which is prerequisite to the use of the first grade computer managed curriculum.

Learning how to sign "on" and "off" the computer was one of the first skills learned by the involved first graders.

The system consists of sets of assessment items for each first grade reading, language arts, arithmetic, and phonics objective. Each of the 176 objectives has a unique prescription code, strategy, timing, and criteria for success. The classroom teacher decides which prescriptions are to be entered for each child in the class, based upon the print-outs of the previous day's computer interactions.

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Samples from each curriculum area follow:

Arithmetic

M11 Given three numerals from zero through ten and an audio message naming one of the numbers, the student identifies the number named.

Audio message: "Point to the number that you hear. Nine"
CRT Screen 6 9 4

Eleven items are presented. Ten must be correct. After two wrong answers, the student is branched out.

M12 Given a picture of familiar objects, the student identifies or types the numeral which names the number of objects.

Audio message: "How many leaves do you see?"
2 3 4

"How many squirrels do you see? Type in your answer."

☐

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Ten items are presented. Nine must be correct. After two wrong answers, student is branched out.

Reading

R41 Given an original story which uses only those words previously taught with multiple choice answer set, the student identifies the answers to five comprehension questions, one from each of the following categories: detail, sequence, cause and effect, main idea, and inference.

Interaction with the computer requires serious concentration for this first grader. He receives immediate feedback from the computer while his teacher is provided with a print-out of his work at the terminal.

FATHER BUNNY'S SURPRISE

Mother Bunny is at work in the house.
Little Bunny wants to help get dinner ready.
Little Bunny said, "I can help make the little cakes!"

Mother Bunny said, "The cakes are ready now.
We have three orange cakes for dinner.
Go look for Father Bunny.
We have something Father Bunny likes for dinner.
The little cakes are a big surprise for Father.
Have Father guess what the surprise is."

Little Bunny said to Father Bunny, "Guess what we have?
Mother and I have a big surprise for dinner."

Father Bunny said, "What color is the surprise?"

Little Bunny said, "The surprise is something orange."

Father said, "I can guess what is for dinner.
I like little cakes.
I like orange.
Is the big surprise little orange cakes?"

Little Bunny said, "The surprise is little orange cakes."

Father said, "I can stop work now.
I am ready for a good dinner."

Mother Bunny said, "Come and see the surprise!
Father, see what is here now."

"The cakes look good," said Father Bunny.
"The cakes are good for a surprise dinner.
The dinner is good, good, good!"

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Audio: "Read the sentences on the screen. Point to the answer with your light pen."

1. What was Father Bunny's surprise?
   big orange cakes
   little orange cakes
   little green cakes

2. Why did Mother make little orange cakes for dinner?
   Father likes little orange cakes
   Mother likes to work
   Father can stop work

3. What was the story about?
   Father makes dinner
   big green cakes
   a surprise dinner

4. Father stops work to ___.
   play ball
   go to a surprise dinner
   help little bunny paint

5. What happened first in the story?
   the cakes are ready
   the dinner is good
   Mother Bunny is at work

All five items presented. Passing score is determined by the teacher.

Phonics

P72 Given a word with the first and last letters missing, both of which are consonants, and an audio message naming the word, the student types the beginning and ending letter of the word.

Audio: "Type the beginning and ending letters of *zoom*.

— OO —

Sixteen items presented. Passing score is fourteen. If three wrong answers are recorded, student is branched out.

A first grader responds to an audio message from the computer. In this activity, he was instructed to count the number of wagons in his booklet and then point to the corresponding number word on the screen.

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Language

L.31 Given three words in the student's reading vocabulary, two of which rhyme and one which does not, the student identifies the word that does not rhyme.

Audio: "Point to the word that does not rhyme."
ten hen home

Ten items presented. If nine are correct, branch to L.32. If three answers are incorrect, the student is branched out.

The results of the use of the CMI system during the 1972-1973 school year were very promising in spite of the fact that only a portion of the activities were coded. The first goal was attained as no student had any difficulty interacting with the computer. The second goal was to increase achievement. The mean grade equivalents for the class on the Metropolitan Achievement Test Primary I Battery given in May were:

	Mean	Standard Deviation
Word Knowledge	2.55	.78
Word Analysis	2.02	.38
Reading	2.19	.56
Total Reading	2.26	.56
Math	2.41	.56

As these scores indicate, the mean for the class was above grade level (1.8) in all areas.

Two first graders, preparing to "sign-on," locate their information cards which contain names and student numbers. A teacher-aide waits to assist any child who experiences difficulty with the operation of the terminal components.

The third goal was to develop beginning self-management skills. The students are responsible for managing their own time between 10 a.m. and 12:30 p.m. each day, participating in group activities (i.e., reading, mathematics) and completing their assigned work. Many observations and pictures substantiate the general impression that these skills are being manifested.

The last goal was to provide the teacher with information and support to aid her in the individualization process. The classroom teacher has been involved in the development of this program and has been enthusiastic about its use. As RAP provides proctor messages on students immediately upon completion of each activity, including the exact incorrect answers, the teacher has the requisite information to individualize the instructional program for all students.

The CMI system was again used in one first grade classroom during the 1973-74 school year. No comparative evaluation was attempted as determination of first grade progress presents a unique problem. When children enter the school system we have very little information about them. Since they are first entering the system, there are no previous records of performance and very little is known about their backgrounds. As there is no information for matching an experimental group with a control group, the statistical technique of comparison is inappropriate.

The Metropolitan Achievement Test, Primary I, was administered in May, 1974. The standardization sample of this test was chosen to "... represent the national population ...". The mean grade equivalents for the 1973-74 class on the Metropolitan Achievement Test were:

	Mean	**Standard Deviation**
Word Knowledge	2.43	.52
Word Analysis	2.64	.74
Reading	2.84	1.02
Total Reading	2.67	.63
Math	2.95	1.09

The information obtained here shows the students performed very well at the end of the year.

Comparison of this kind does not allow the type of conclusion which can be made from a more controled study. The lack of pre-school information, discussed earlier, precludes a more meaningful analysis. There is the possibility that the differences between the norm group and the CAI group were due to other factors. Unfortunately, as the new computer equipment does not support an audio terminal component, the use of the first grade CMI program will be discontinued until some future date.

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Children involved in the first grade computer project move individually from one activity to another during the morning. Upon completion of all assigned work, they choose quiet activities while others finish their assignments.

2. Least Common Multiple

This instructional module, designed by Laura Stoskin during the 1971-1972 Teacher Training Program, was considered to meet a need in the elementary school. It is to be included at a future date in the fractional diagnostic and drill package as a tutorial program for those students who do not pass Concept Tests V (part 2), VI or VII.

Since there are several ways to find the least common multiple, two methods are taught in this program. The student may successfully pass the program by pursuing only the simpler path to the terminal objective. However, a more able student, as identified by the classroom teacher, will learn two methods and use the prime factorization method to attain the terminal objective of the program.

Terminal Objective: Given ten pairs of natural numbers in which each number is a multiple of 2, 3, or 5 and less than or equal to 16, the student constructs the least common multiple for at least 9 pairs either by (1) Program A or (2) Program A and B.

Entering Behavior: Given five problems, the student multiplies a two-digit number less than or equal to 16 by a one-digit number with 100 per cent accuracy.

LEAST COMMON MULTIPLE

HIERARCHY

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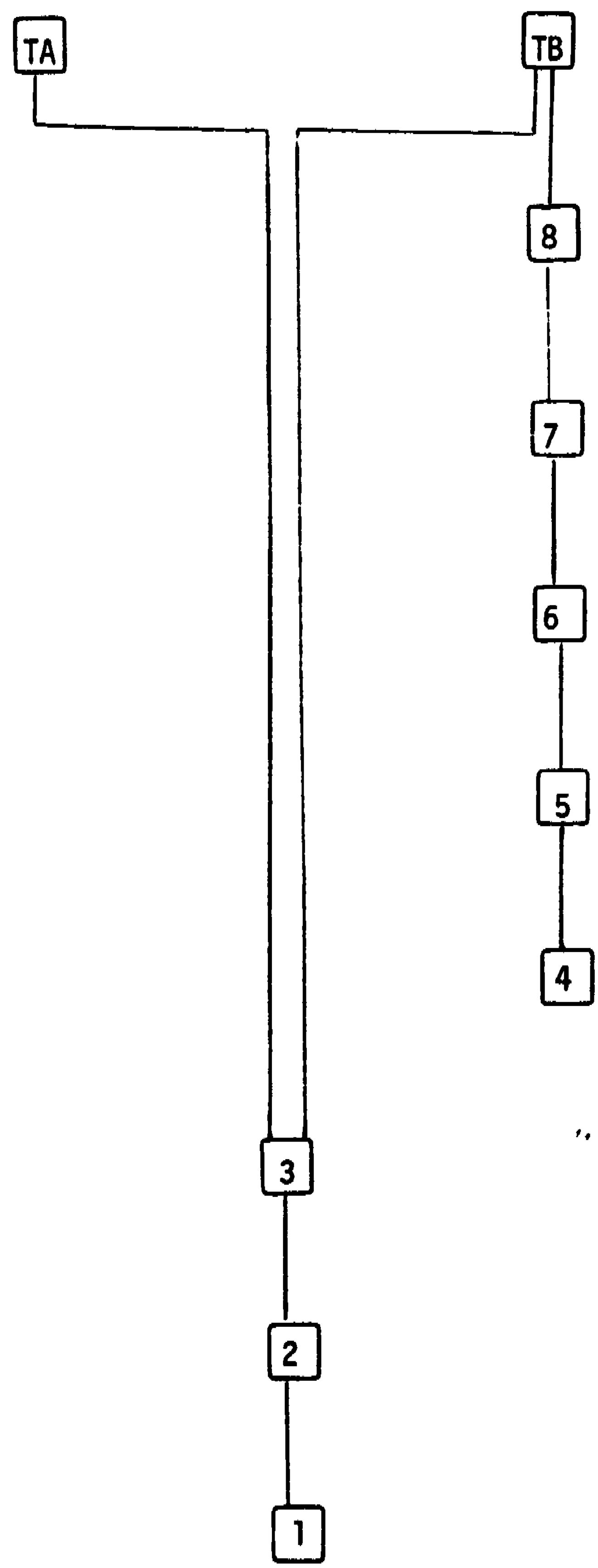

ERIC

Enabling Objectives:

Program A

1. Given a pair of natural numbers in which each number is a multiple of 2, 3, or 5 and less than or equal to 16, the student lists the first 10 multiples for each number.

   Example: 2 4 6 8 10 12 14 16 18 20

2. Using the two lists of constructed multiples from objective one, the student lists the common multiples.

   Example: 2 4 6 8 10 12 14 16 18 20

   3 6 9 12 15 18 21 24 27 30

   Answer: 6 12 18

3. The student identifies the least common multiple from the lists of common multiples from Objective 2.

Program B

4. Given 5 natural numbers less than or equal to 16, the student identifies those which cannot be divided by any numbers except 1 and the number itself.

   Example: 10 <u>3</u> <u>7</u> <u>5</u> 8

5. Given 5 composite numbers less than or equal to 16, the student factors each in any way.

   Example: 16 = 2 X 8   16 = 4 X 4

6. Give 5 composite numbers less than or equal to 16, the student factors each into prime numbers.

   Example: 16 = 2 X 2 X 2 X 2   9 = 3 X 3

7. Given 5 pairs of natural numbers in which each number is a multiple of 2, 3, or 5 and less than or equal to 16, the student factors each composite number into prime numbers and identifies within each pair the common prime factors.

   Example: 9 = 3 X 3   12 = 2 X 2 X 3
   6 = 2 X 3   8 = 2 X 2 X 2

8. Given 5 pairs of natural numbers as above, the student constructs the least common multiple by using the prime factorization method.

3. Problem Solving

A review of the results of the county-wide standardized testing program in the elementary school indicated a need for more emphasis on the development of problem-solving skills. The fourth grade was selected as the appropriate place to introduce a concentrated problem-solving program because of the students' experiences with whole numbers. By fourth grade most students have mastered the whole number operations of addition and subtraction, have had considerable experience with multiplication, and have been introduced to division. In fourth grade, addition and subtraction are reviewed; multiplication is mastered; division with one-place divisors is usually mastered; and division with two-place divisors is introduced.

In designing this program for the fourth grade, the goals were to individualize the problem-solving experience and to improve the application of computational skills in solving problems. In order to accomplish these goals, groups of 5 comparable problem sets were written to follow the 18 review tests in the subtraction, multiplication, and division sections of OWN. The student works a problem set on paper and then uses the computer terminal to record his answers. Data from student responses can be analysed for use by teachers and program authors in assessing the effectiveness of the problem-solving program.

Each set consists of ten problems: four one-step problems, a no-number problem situation for which the student must indicate the required operation, two two-step problems, a challenging problem, and two problems dealing with measurement and graph interpretation. The computational skills required in solving these problems may be taken from any objective in the developmental sequence preceding the OWN review tests.

The following representative problem set is one of the five which follows the first review test in multiplication.

Solve these problems

1. It is September. School has just begun. Steve must buy $3.25 worth of school supplies. If he starts out with $5.00, how much money will he have left after buying his supplies?

2. It is October now. Halloween is here. Oscar is buying taffy apples for his Halloween party. If each taffy apple costs $.11 and he buys 5 of them, how much money does he spend?

3. Now it's November and the Thanksgiving holidays have arrived. The turkey has 2 more hours to roast in the oven. How many minutes before the turkey is done? Hint: 1 hour = 60 minutes

1.?

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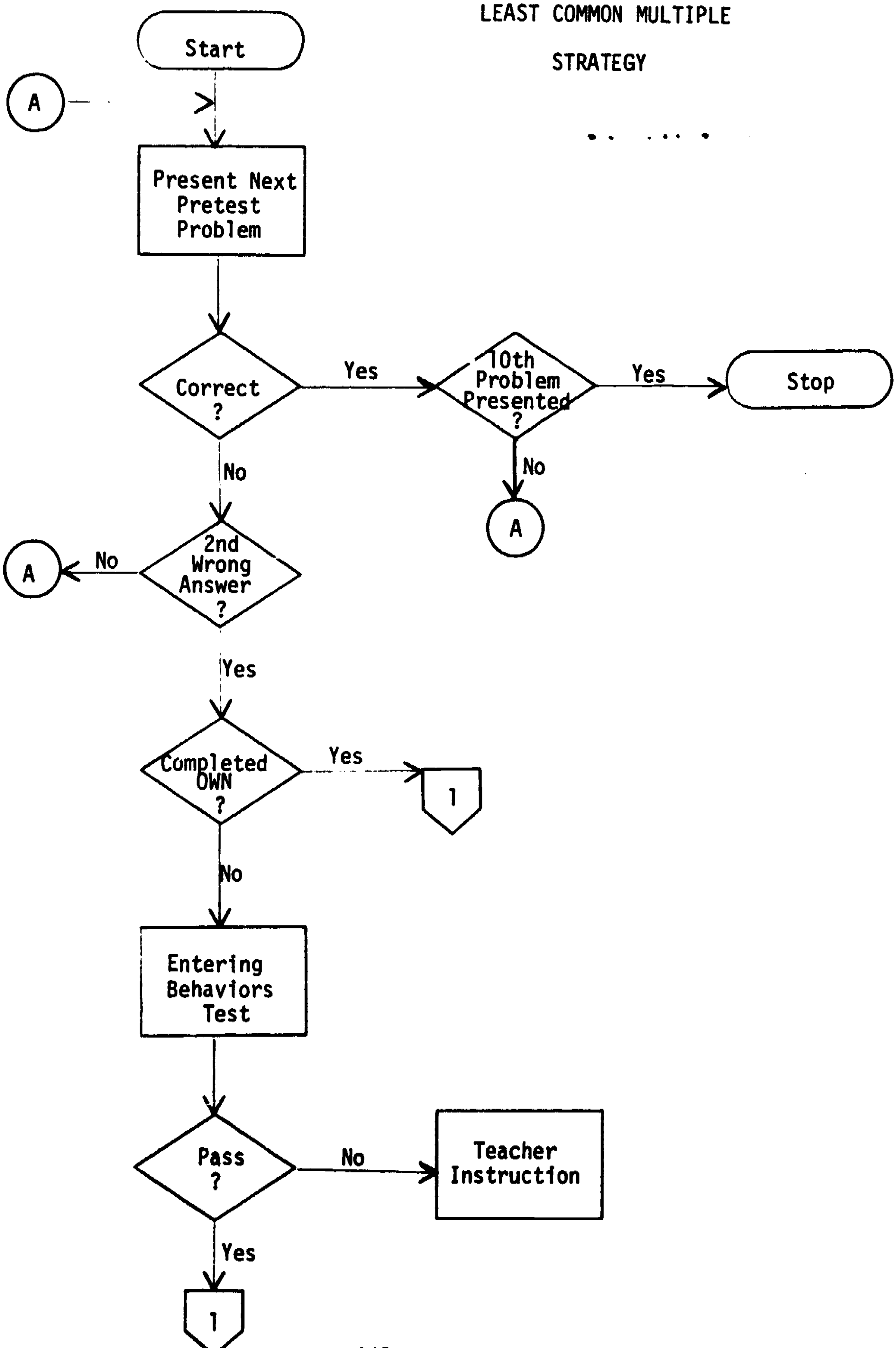
LEAST COMMON MULTIPLE

STRATEGY



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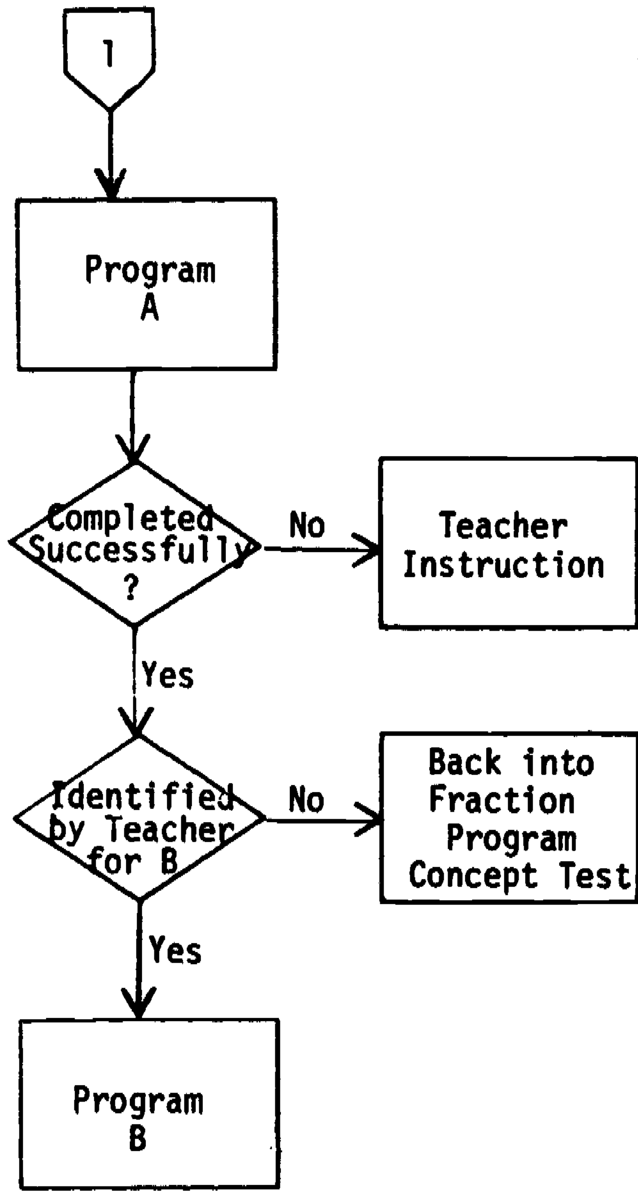

4. December is here and so is Christmas. Danny is counting the money he was given as gifts. He received $5.50 from Aunt Dora, $10.00 from Uncle David, $25.00 from Daddy and $1.50 from sister Debbie. How much money did he receive altogether?

a) add
b) subtract
c) multiply
c) divide

6. February, the shortest month of the year with only 28 days, is here. Frank is trying to memorize his multiplication tables through the 11's facts by the end of the month. If he spends two days studying each of the 11 tables, how many days will he have left for review?

7. March comes in like a lion. Speaking of lions, the new one at the zoo eats a lot of meat. Last week he ate 21 pounds on Monday, 26 on Tuesday and 29 on Wednesday. If he ate 142 pounds that entire week, how much would he have to have eaten during the remainder of the week?

8. April showers come next. It rained so much that the pond water rose 2 inches on April 5th, 2 more inches on the 7th, 1 more inch on the 9th, 4 inches on the 10th, and 3 inches on the 12th. How many feet did the pond water rise altogether? Hint: 12 inches = 1 foot

9. It's really spring now. May is here. Susan wants to go out to play but she has to do her homework first. She will have to spend 40 minutes on each subject and she has 5 subjects. If she gets home at 3 o'clock and eats dinner at 6:30, how much time in between will she have to play?

10. Use the Set J graph to answer the following question. On a hot day in August, Judy set up another lemonade stand. She sold twice as much lemonade as she did on the July Sunday shown on the graph. How much money did she collect on the August day?

Graph for Set J

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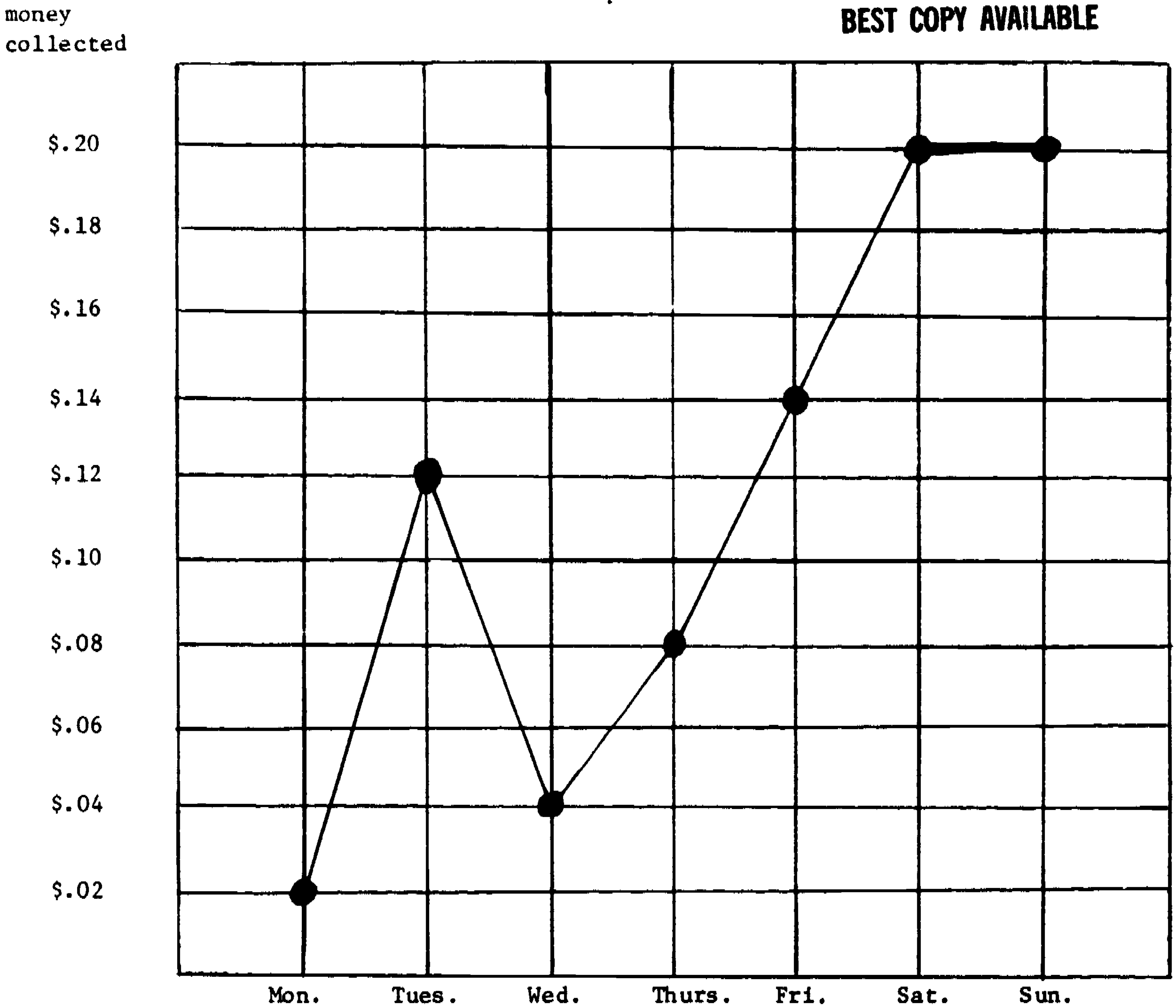

Judy's Lemonade Stand

B. SECONDARY

1. Mathematics

Curriculum development efforts in the secondary mathematics area have been centered around three major concerns:

1. The continued development of a year-long Computer-Managed Instruction Geometry Program.

2. The development of a year-long CMI Algebra I Program.

3. The development of a tutorial modular instructional package to coincide with the tenth unit of the geometry program, Area and Volume of Plane and Solid Figures.

The CMI Geometry Program under development is a continuation of that documented in the *Title III Final Report.* A geometry design team consisting of three experienced teachers met with team leader Thomas E. Robinson one day every two weeks to complete CMI geometry units, revise logic units, write objectives for individual geometry units, and debug operational geometry units. Members of the design team were experienced classroom teachers who had worked with the CAI Program for an extended period of time: Anne Roger and Mary Weikel, junior high mathematics teachers whose work in curriculum design at the program began in 1969, and Karl Figert, geometry teacher who not only assisted in designing the modules but also implemented the CMI geometry curriculum with his classes at the program high school. A complete description of the materials and objectives used in the CMI Geometry Program is included in the OPERATIONAL Secondary Activities section of this report.

Considering the direction that the CAI Program could take in the immediate future, a need was felt for the development of a CMI Algebra I curriculum similar to that of the Geometry program. Its structure and design would follow the format established by the geometry program. Therefore, during the fall of 1972, Thomas E. Robinson, secondary mathematics CAI specialist, headed a design team which assumed the responsibility for developing the CMI Algebra I Program. Two high school mathematics teachers assisted in this task: Thomas Kautz, mathematics teacher at Woodward High School, and Maggie Escatell, mathematics teacher at the program high school. Thomas Kautz had been trained in the 1971-1972 Teacher Training Program where he designed a package titled SOLVING TRIANGLES – THE LAW OF SINES. The design team was to:

1. Define the topics or units that should constitute the basis for an Algebra I curriculum, maintaining MCPS guidelines.

2. Perform a task analysis on each topic and write the objectives necessary for attaining the terminal objective(s)

3. Arrange the objectives by unit into a learning hierarchy

4. Create at least two sets of assessment test items for each objective

5. Create a diagnostic test for each unit

6. Create a composite test for each unit

The following 11 units were identified as constituting an Algebra I curriculum:

I. Sets, Symbols, Systems, Operations, and Number Lines

II. Open Sentences

III. Directed Numbers and Absolute Value

IV. Operations with Monomials and Polynomials

V. Solving Open Sentences

VI. Word Problems

VII. Graphing and Systems

VIII. Multiplication and Factoring of Polynomials

IX. Rationals and Ratio and Proportion

X. Radicals (Real Numbers)

XI. Quadratics

Unit I of the Algebra I CMI program was coded into COURSEWRITER II during the spring of 1973. This allowed time for pilot testing the material before the termination of that academic year. Seven Algebra I students from Einstein High School participated in this study during the week of May 21, 1973. An additional seven Algebra I students at Newport Junior High School pilot tested the same material the following week.

Some suggested changes were concerned with the formatting of material presented. Results from both sessions, however, were favorable; and the instructional strategy was deemed valid.

The remaining area of developmental concern deals with the work in progress on a tutorial unit for geometry in Area and Volume of Plane and Solid Figures. The design team members responsible for producing the complete CMI Geometry program are concurrently developing this tutorial package. By virtue of having the objectives and hierarchy previously established, efforts during the spring of 1973 were concentrated primarily on instructional strategy. Presently, this work remains under development.

The task analysis performed on Unit I, Sets, Symbols, Systems, Operations, and Number Lines, yielded 50 enabling objectives. These objectives, the learning hierarchy, and the general instructional strategy follow.

The terminal objectives of this unit are:

1. The student constructs the graph of the intersection and/or union of two sets of real numbers on a given number line. (See Objectives 31 and 33.)

2. Given an algebraic statement, the student names the property of real numbers that justifies the statement. (See objective 50.)

ERIC

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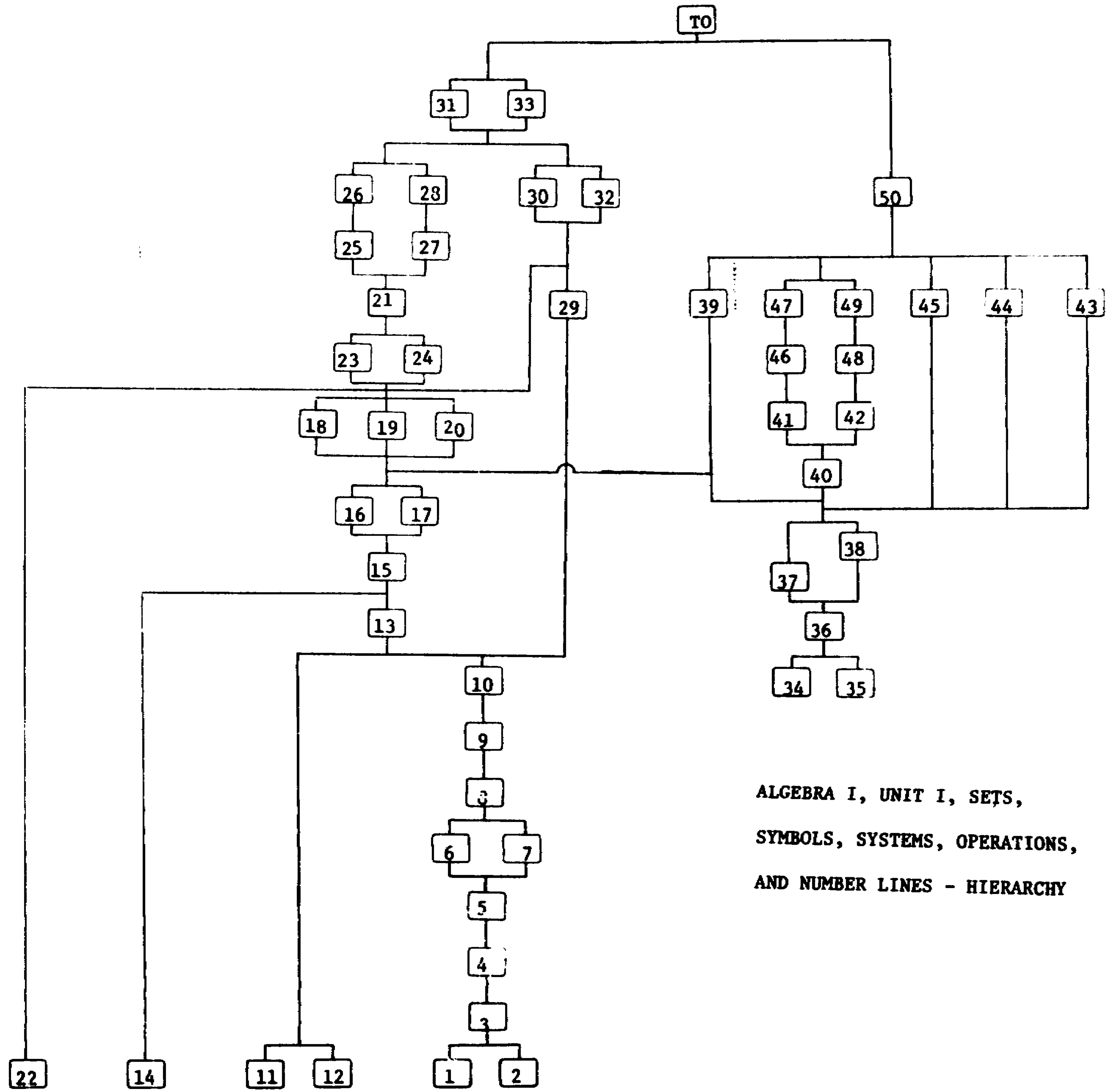

ALGEBRA I, UNIT I, SETS, SYMBOLS, SYSTEMS, OPERATIONS, AND NUMBER LINES - HIERARCHY

Objectives

1. Given nine symbols representing numbers, the student identifies those two which name natural numbers.

2. Given nine symbols representing numbers, the student identifies those three which name whole numbers.

3. Given nine symbols representing numbers, the student identifies those five which name integers.

4. Given four statements, the student selects the one that best defines the set of real numbers.

5. Given five symbols representing numbers, the student types the letter(s) of the set(s) that contains the given number. He must score four out of five.

   (N = natural)

   (W = whole)

   (I = integer)

   (R = real)

*________________

6. Given a number line from -5 to 5 by units of 1, the student (a) names the coordinates of two given points; (b) names the coordinate of a point a specific number of units to the right or left of a given point; and (c) names a point halfway between two given points.

7. Given a number line from -5 to 5 by units of 1, the student (a) names the graph of two given numbers; (b) names the graph of a point a specific number of units to the right or left of a given number and (c) names the graph of a number halfway between two given points.

____

8. Given a list of four integers, the student identifies the largest and the smallest.

9. Given a list of four numbers (fractions and decimals), the student identifies the largest and the smallest.

10. Given five incomplete number sentences containing rational numbers, the student types the symbol (=, >,<) that will make a true sentence. He must score four out of five.

____

11. Given a list of six symbols, the student identifies the symbol for "element of."

12. Given a list of six symbols, the student identifies the symbol for "not an element of."

*Indicates CLUSTERAL BREAKS

13. Given a set, a symbol ($\in$, $\notin$), and a possible element of the given set, the student determines whether the statement is true or false. He must score four out of five.

---

14. Given a list of five symbols, the student identifies the symbol for "null set."

15. Given the rules for five sets, the student identifies the sets that are null sets.

---

16. Given the rules for three sets with less than six elements, the student types a roster for each set.

17. Given the rosters for five sets and the rules for the five sets, the student matches the roster with the correct rule.

---

18. Given five pairs of sets, in rule or roster form, the student types = or $\neq$ to make a true statement. He must score four out of five.

19. Given four pairs of sets, in rule or roster form, the student types *yes* or *no* to determine whether the sets can be put in one-to-one correspondence. He must score three out of four.

20. Given six sets, in rule or roster form, the student types *F* or *I* to determine whether the given set is *f*inite or *i*nfinite. He must score five out of six.

---

21. Given a set of three elements, the student writes the subsets.

22. Given a list of five symbols, the student selects the symbol for subset.

23. Given four sets and a subset of each set, the student identifies whether the subset is proper or improper.

24. Given four statements, the student types $\subset$ or $\in$ to make a true statement.

---

25. Given four pairs of finite sets written in roster form, the student types the elements in the union for each pair of sets. He must score three out of four.

26. Given the indicated union of three pairs of sets written in roster or rule form, the student matches the given expression with the equivalent rule.

27. Given four pairs of finite sets written in roster form, the student types the set that is the intersection of each pair of sets. He must score three out of four.

28. Given the indicated intersection of three pairs of sets written in roster or rule form, the student matches the given expression with the equivalent rule.

---

29. Given the graphing symbols (•, ○, —, >, <) each contained on a number line and the corresponding word descriptions, the student matches the symbols and the word descriptions.

30. Given four sets, the student constructs the graphs of the sets on given number lines. He must score three out of four.

31. Given three pairs of sets, the student constructs the graph of the union or intersection on a given number line.

32. Given three graphs on the number line, the student matches the set which corresponds to each graph.

33. Given three graphs on the number line which are the intersection or union of sets, the student matches the set which corresponds to each graph.

---

34. Given four exponential expressions, the student types the equivalent expanded form.

35. Given five arithmetic expressions containing a product of equal factors, the student writes the equivalent exponential form. He must score four out of five.

36. Given four expressions containing powers of whole numbers, the student writes the simplest equivalent form. He must score three out of four.

---

37. Given four arithmetic expressions with grouping symbols, the student types the simplest equivalent form. He must score three out of four.

38. Given four arithmetic expressions without grouping symbols, the student follows the rules for order of operations to write the simplest equivalent form. He must score three out of four.

---

39. Given four sets and an operation for each set, the student determines which two of the sets are closed for the operation.

40. The student names the identity elements for (a) addition and (b) multiplication.

41. Given four rational numbers, the student types the additive inverses.

42. Given four numbers, integers or fractions, the student types the multiplicative inverses.

43. Given eight statements, the student selects the statement that is an example of the commutative property.

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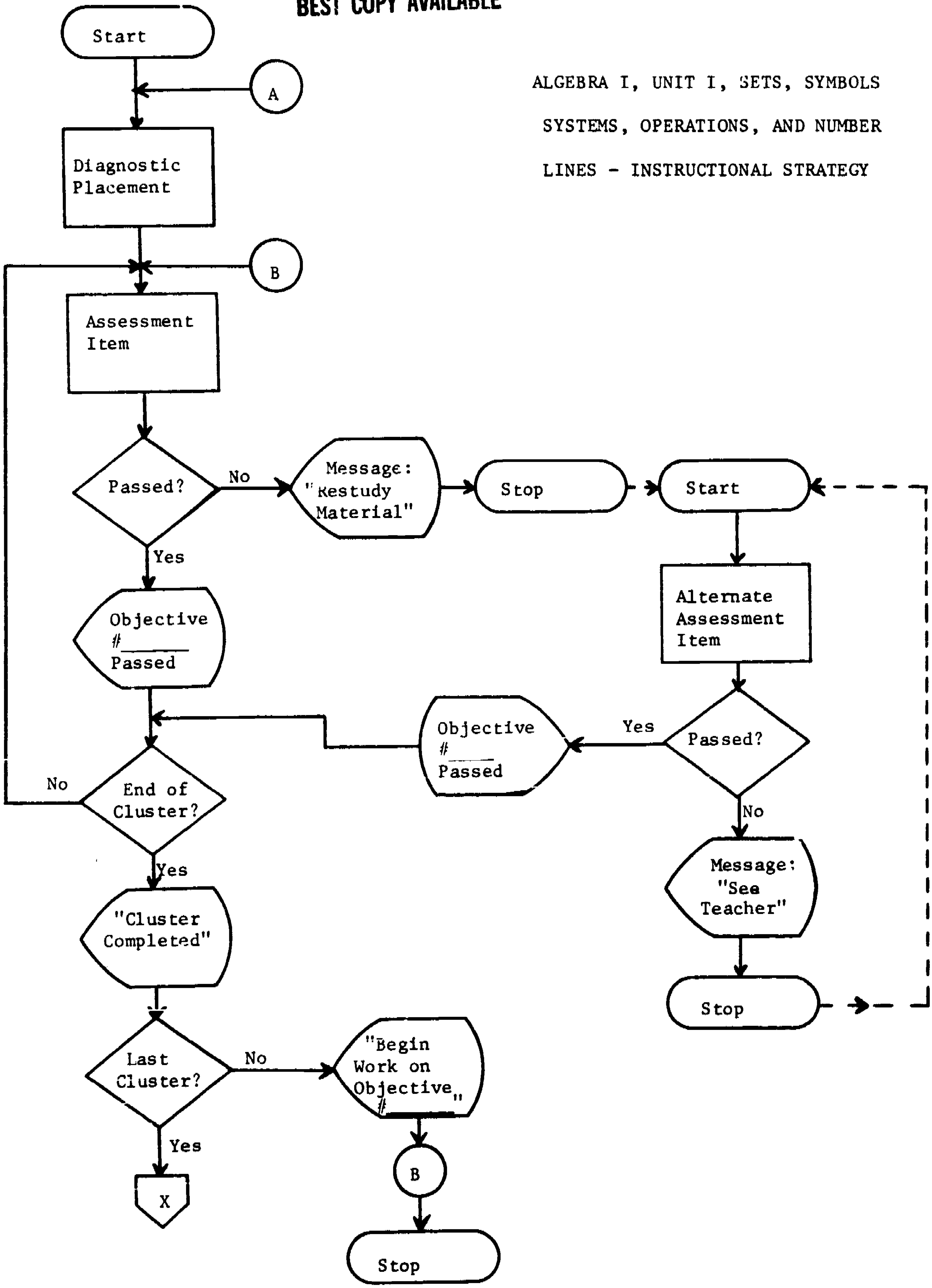
ALGEBRA I, UNIT I, SETS, SYMBOLS SYSTEMS, OPERATIONS, AND NUMBER LINES - INSTRUCTIONAL STRATEGY



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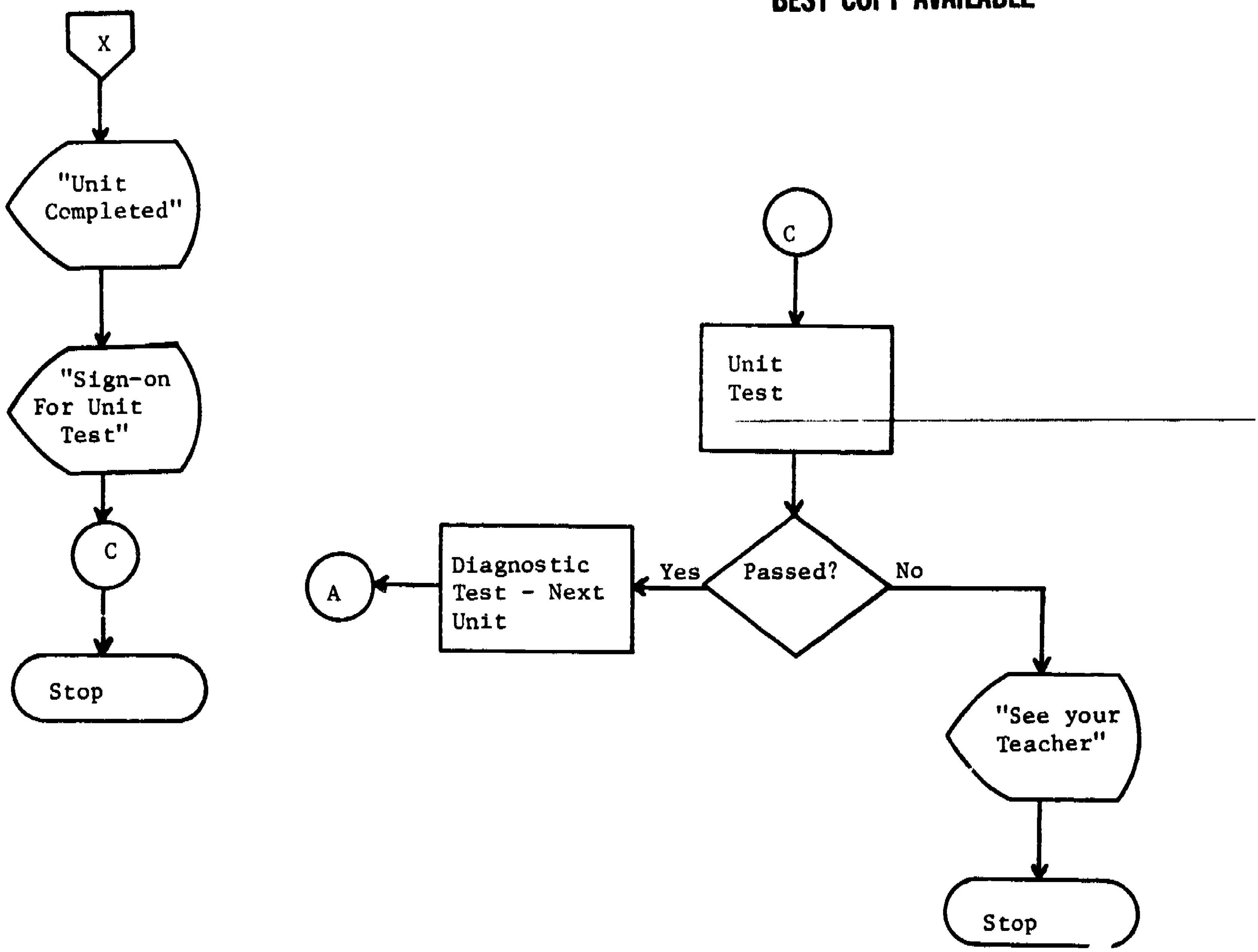


44. Given eight statements, the student selects the statement that is an example of the associative property.

45. Given eight statements, the student selects the statement that is an example of the distributive property.

46. Given eight statements, the student selects the statement that is an example of the additive inverse.

47. Given eight statements, the student selects the statement that is an example of the additive identity.

48. Given eight statements, the student selects the statement that is an example of the multiplicative inverse.

49. Given eight statements, the student selects the statement that is an example of the multiplicative identity.

50. Given six statements, the student writes the name of the property which justifies each statement. He must score five out of six.

Additions

In an effort to further assess the computer's capabilities related to large-scale testing, an Algebra II examination was developed by the mathematics department at Albert Einstein High School. This examination was first given in June, 1971, revised during the 1971-1972 school year, and since used as the final examination for all Algebra II students. It contains four possible items with approximately the same indices of difficulty and discrimination for each of the 25 terminal objectives for the Algebra II course. This examination was designed to allow each student to be tested individually and receive immediate results on his performance.

2. **English**

A design team headed by Alex Dunn was formed in the fall of 1972 to write performance objectives in the area of English and, subsequently, develop modular instructional packages for the computer. Two supporting teachers were identified to assist in this initial effort: Anne Wolfe, an experienced eighth grade teacher at Parkland Junior High School, and Robert Gallagher, an English teacher at the Program High School who had participated in the 1971-1972 Teacher Training Program. Meeting on a released time basis one day every two weeks, the design team assessed the effectiveness of both procedures and materials in terms of their usefulness for English students. Discussions were held on what concepts and skills should be taught, the preassessment of entry skills, and the development of a research design that would allow the English teacher to monitor student progress.

As experienced classroom teachers whose daily contact with students in a variety of writing situations, the design team decided to develop programs in the areas of punctuation and subject-verb agreement. It was felt that such programs, in addition to providing support for the English teacher, would be applicable to secondary students throughout the school year either as a tutorial or drill and practice program.

SUBJECT-VERB AGREEMENT is a tutorial, drill and practice program which is designed for junior high English students, but with tutorial applications for upper secondary classes. The program is still in the developmental stages.

Terminal Objective:

Given twelve sentences offering a choice between singular and plural forms of a verb, the student chooses the form appropriate to the number of the subject in at least ten of the cases.

Entering Behaviors:

1. Given an unfamiliar word, the student defines it and writes its various forms with the aid of a dictionary.

2. Given simple sentences in regular word order, the student writes *S* on simple subjects and *V* on main and auxiliary verbs with 75 per cent accuracy.

3. Given a sentence with compound subjects and verbs, the student identifies all subjects and verbs.

4. Given a question, the student identifies the subject.

5. Given a sentence containing *here* or *there* in an expletive sense or *where* in an interrogative sense, the student inverts the sentence to a regular SV form and identifies the subject.

Enabling Objectives: (With 75 per cent accuracy)

1. Given sentences in which he has identified the simple subject and its number, the student chooses a verb similar in number to the subject.

2. Given sentences involving nouns with irregular singular and plural forms or unfamiliar words as subjects, the student identifies the meaning and the number of the word forms with the aid of a dictionary.

3. Given sentences with collective nouns as subjects, the student identifies the meaning of the noun as plural or singular in the context of the rest of the sentences and chooses the appropriate verb.

4. Given an idenfinite pronoun as the simple subject of a sentence, the student chooses a verb appropriate in number.

5. Given sentences in which the subject and the predicate nominative differ in number, the student chooses a verb matching the subject in number.

6. Given sentences in which nouns or phrases separate the simple subject from the verb, the student chooses a verb similar in number to the subject.

7. Given the title of a single work as the subject of a sentence, the student chooses a singular verb.

8. Given sentences in which two or more nouns have a singular meaning as one item, the student identifies both nouns as part of one item and choose a singular verb.

9. Given sentences in which nouns expressing quantities or amounts are subjects, the student identifies them as, usually, singular and chooses an appropriate verb.

10. Given sentences containing *here* or *there* in an expletive sense, the student identifies the subject and chooses the appropriate verb.

11. Given a sentence with two or more singular or plural nouns as compound simple subjects connected by *and*, the student chooses a plural verb.

12. Given a sentence with two or more singular subjects joined by *or, nor, either . . . or,* or *neither . . . nor,* the student chooses a singular verb.

13. Given a sentence with alternate subjects of any number joined by *or* or *nor*, the student identifies the last simple subject as the one which controls the number of the verb.

COMMA PUNCTUATION IN RESTRICTIVE AND NONRESTRICTIVE PHRASES AND CLAUSES is a tutorial package designed and developed by Robert Gallagher for English students in Grades 10-12. The program has not yet been coded.

Terminal Objective:

Given sentences containing restrictive and nonrestrictive phrases and clauses, the student inserts commas before and after those phrases and clauses which require such punctuation.

Entering Behaviors:

A. The student identifies the comma in a given list of sentences containing various punctuation marks.

B. Given a series of word constructions, the student chooses those constructions which are complete sentences.

C. Given a series of word constructions, the student chooses those constructions which are phrases.

D. Given a series of word constructions, the student chooses those constructions which are clauses.

Enabling Objectives:

1. Given a series of sentences which contain phrases, the student identifies the phrases.

2. Given a series of sentences which contain dependent clauses, the student identifies the dependent clauses.

3. The student defines "nonrestrictive" as that which does not limit or place within boundaries.

4. The student defines "restrictive" as that which limits or places within boundaries.

5. Given sentences, some of which contain nonrestrictive phrases, the student identifies the nonrestrictive phrases.

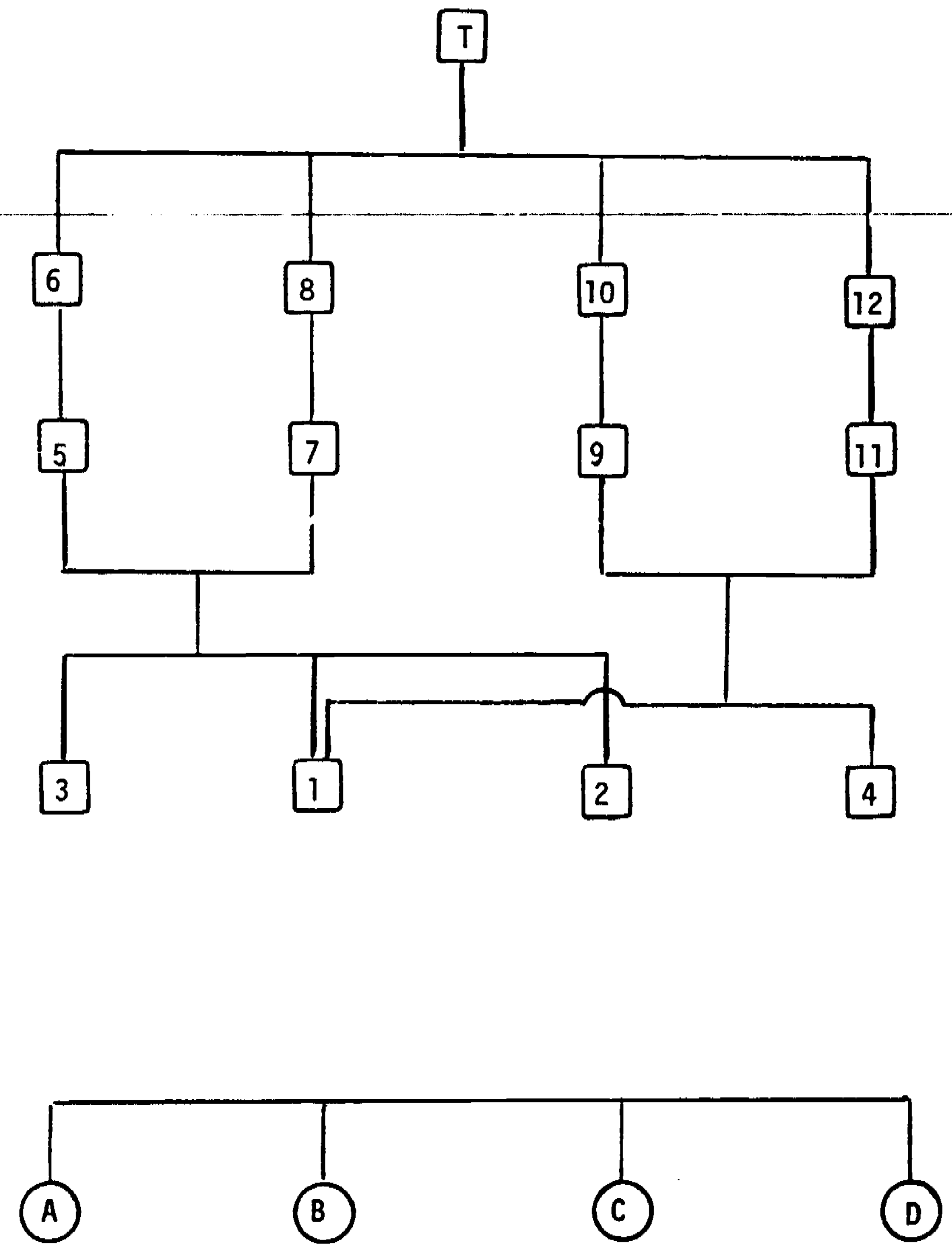
6. Given sentences, some of which contain nonrestrictive phrases, the student inserts commas before and after such phrases.

7. Given sentences, some of which contain nonrestrictive clauses, the student identifies the nonrestrictive clauses.

8. Given sentences, some of which contain nonrestrictive clauses, the student inserts commas before and after such clauses.

COMMA PUNCTUATION **BEST COPY AVAILABLE**

Hierarchy



ERIC

9. Given sentences, some of which contain restrictive phrases, the student identifies the restrictive phrases.

10. Given sentences, some of which contain incorrectly punctuated restrictive phrases, the student identifies those commas which should be removed from before and after such phrases.

11. Given sentences, some of which contain restrictive clauses, the student identifies the restrictive clauses.

12. Given sentences, some of which contain incorrectly punctuated restrictive clauses, the student identifies those commas which should be removed from before and after such clauses.

3. French

In another curriculum area, a second CAI French package was designed and developed during the 1972-1973 school year by Mary Schneck, teacher at Charles W. Woodward High School. Miss Schneck participated in the 1972-1973 Teacher Training Program where she began designing a French MIP as part of her training in the program. In the fall of 1972, she was identified as a supporting teacher and continued her work on the French module. This tutorial program, FRENCH RELATIVE PRONOUNS *QUI, QUE, LEQUEL, DONT,* has as its target population French III students.

The terminal objective is: Given, in written form, 20 pairs of complementary simple sentences, the student combines these simple sentences with 90 per cent accuracy into complex sentences by use of the appropriate relative pronoun.

This program has been completed but has not been coded.

C. READING

The CAI Program's interest in reading came about as a result of the ever increasing number of students in public schools who need reading assistance. Statistics show that nearly seven million children now in school need help in reading. In fact, almost half of the children in large urban schools are reading below grade level, and nearly 90 per cent of the school droupouts are classified as poor readers. These and other findings led Anne Tipton, teacher specialist in reading curriculum, to look into various methods in which reading was being taught. Research indicated that there existed no standard or generally accepted systematic program through which every child could be screened for a learning disability. In addition, remedial methods were found to rest on varied and shaky hypotheses and were rarely subjected to scientific evaluation on an empirical basis. Conventional phonics texts, it was observed, had never come close to presenting a good beginning in teaching phonics. Furthermore, research into existing methods of teaching phonics revealed the beginning steps to be far too difficult because they were begun at such an advanced level. Much is involved in learning speech sounds. The first steps in reading should be taken slowly and repetitively but with tools that have meaning and can be used in decoding similar words over again and again. In fact, the entire alphabet is probably too much to present in one academic year. Some critical questions should be considered. Why work on beginning sounds for months before working on ending sounds? Are children expected to learn just a part of the word? What about the whole word? It appears that for many children too much has been given too soon.

According to available research, only one-half of the world's languages has been represented in graphic codes. Historically, writing first began with a picture to represent a situation; then a picture or a sign was used to represent each word. Later, a picture or sign was substituted for each syllable; and finally, the separate phonetic units of syllables were symbolized by signs. A series or set of such signs is called an "alphabet."

The set of 26 letters or graphic shapes that we use is called the English alphabet. Following are some elements of this graphic code or alphabet. Each letter has both an upper and lower case form. For example, *A E Q* may be written ***a e q***, and any letter may be printed in typographic, (e.g. a) manuscript (ɑ), or cursive (*a*) style. This amounts to at least six possible graphic forms for each, depending upon the style. Using our existing methods of teaching reading, it means the child must learn to recognize a grand total of 156 possible graphic forms before he is able to read.

The 26 letters can represent over 43 sounds commonly found in words, and some letters represent more than one sound. For instance, *a* has a different sound in the following words: *fate, had, star, dare*, and *about*. On the other hand, the same sound can be represented by many different letter combinations: *a, ai, ay, ea, ei*, and *uet*. Some letters have no sound of their own: *c* as in *cake*, *q* as in *quit*, and *x* as in *box*. Other letters are silent: *k* as in knife, *gh* as in *high*, and *g* as in *gnaw*.

In learning the letters, the child must be able to recognize the distinguishing characteristics of both curved and straight lines; number of strokes; and horizontal, vertical, and slanting strokes as well as the left-right position of the stroke. He must also be able to distinguish the relative size of the curved portions and positions as combined with the strokes.

Then there are the nonalphabetic signs of which there are three types:

1. Word signs: numerals (1) and its corresponding word *one*

2. Abbreviations: *Dr.* for *doctor, Md.* for *Maryland*

3. Punctuation marks: . ! ? : ; "

4. Left-right sequence: word order, *John loves Mary*; words, *saw-was*; individual letters, *b-d*.

The vast amount of material a child is expected to digest in just one or two years is overwhelming. Obviously, some children do not grasp the material and consequently never learn to read. Those children who have experienced failure know that they have been unable to do specific work which others accomplished with apparent ease. As a result, they frequently resort to many disguises to hide their humiliation. The discouraged child who believes himself a failure is in desperate need of experiencing success.

If children are to be taught the effective use of the graphic English code in reading and writing tasks, it is essential that (1) the code be analyzed carefully, (2) *all* elements of the code be included in beginning reading programs, (3) an analysis be made of the reading process into component and possibly hierarchical tasks which will produce a checklist of observable behaviors found necessary to perform the reading act, and (4) a plan of action designed to simplify the hierarchical tasks in breaking the graphic language code.

Before a child ever experiences failure in reading, he can start with a very simple task and build on to another simple task of recognizing and combining units of the auditory and graphic language through the process of the systems approach to reading instruction. It will give them an eagerness to learn and a feeling of confidence and enjoyment. Therefore, there will be no need for remediation or diagnostic prescriptive teaching.

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D. COMPUTER LITERACY

By 1980 it is predicted that 3 per cent of all individuals in the United States will be in occupations directly related to the computer. Presently less than one-half of 1 per cent of students in the secondary schools in the United States have any access to a computer terminal in their schools. Schools are graduating computer illiterate adults. To meet this need, in MCPS the CAI Program is developing four mini-courses designed to provide computer literacy to students in Grades K-12. The program has also administered a Time-Sharing Project in nine secondary schools, providing computer literacy through on-line computer services with a commercial organization.

The four mini-courses under development include a Computer Awareness Program designed for children in K-1, "How the Computer Works" for Grades 5 and 6, "Vocational and Social Implications of Computers" for Grade 8, and "Learning a Programming Language and Using It for Problem Solving" designed for students in Grades 9-12. The Computer Awareness Program and secondary school problem solving course are now operational in a limited number of schools.

The descriptions of the objectives and implementation of these mini-courses are contained in this section. The objectives of an upper elementary school course are also included but not the related instructional activities since this program has not been pilot tested and validated with students. Information for the eighth grade course is being accumulated but no developmental work has been started.

1. Computer Awareness (K-1)

This package consisted of two activities developed for children in the kindergarten or first grade. The objectives of these activities were to provide the opportunity (a) to participate in an interactive computer program experience at a visual terminal and (b) to visit a computer facility in which a short demonstration, description, and discussion about how the program with which the students interacted received input, was stored, and produced output.

In addition, the first grade students who were enrolled in the computer-managed instruction class were oriented to terminal use through this experience. This required a program in which the first graders would use the headsets to hear an original story narrated with a number of short oral directions. They responded by turning the pages in a picture book during the narration and using the light pen to react to stimuli on the screen. Subsequently, this experience was followed by a walking trip in small groups to the computer facility. The children asked many questions about the environment in which the computer was housed, i.e., Why was it so cold? and Why was the floor raised? All first graders responded to the use of the terminal and trip to the facility in a positive manner. They also demonstrated their ability to use the terminals with no difficulty. As a result, the same activity was tried with four-year olds in a nursery school conducted at the high school. Only two of these children showed any ability to follow the oral directions and the others depended entirely on the high school students for assistance.

2. **Computer Language and Problem Solving (9-12)**

The objectives of this course are as follows:

I. The student demonstrates an understanding of the restrictions and human limitations placed upon a computer system by answering five true or false questions related to this concern. (4 or 5 correct)

II. The student demonstrates an understanding of the use of computer systems for massive data storage, instantaneous information retrieval, complex equation computation and analysis by answering five questions designed to measure his knowledge of these subjects. The test questions demand a student analysis of job functions in relationship to their performance at the most reasonable cost, with the greatest amount of accuracy, and in the shortest period of time. (Criteria 4 or 5 correct)

III. Given a schematic time-line with six dates and three ten-year intervals located, and a list of nine inventors, or processes, or computer systems (lettered A-1), the student writes the letter of the historic event above the date that best approximates time of development. (Correct or 2 letters confused)

IV. Given a flowchart, the student demonstrates a tracing of the logical flow by writing the output required at the various locations.

V. The student demonstrates a capability for programming (in any language) by writing a branching program to perform the functions requested in a designated problem situation. The program developed may contain no logistical errors but may contain as many as two syntactical errors.

The report describing the experiences of the pilot testing during the 1972-73 school year in seven senior high schools and two junior high schools is included in the Appendix.

3. **How the Computer Works (5-6)**

This mini-course's objectives were based upon the results of an oral discussion and survey of what upper elementary school students wanted to know about computers. In determining the method of evaluating the effectiveness of such a course, teachers designed "test" items which reflected the wide interests and activities of students in this age group. The items also allowed for the choice of ways to meet each objective.

I. The student demonstrates an understanding of flowcharting and the computer fundamental concepts of memory address and modification, arithmetic functions, input-output techniques, and looping by completing at least one of the following:

   1. Given a problem, the student flowcharts a method of solution and writes a computer program for the solution in the language taught.

   2. Given a statement of a problem and a programmed solution (written in the language taught) with two errors, one syntactical and one logical, the student corrects the statements containing errors to meet the conditions of the problem and flowcharts the solution.

   3. Given a computer program without errors and written in the language taught, the student writes the output of the program and draws a flowchart.

II. The student demonstrates an understanding of the changes that characterize the history of computers from 1946 to the present by completing at least one of the following:

   1. The student writes a story tracing the history of computers from 1946 to the present.

   2. The student constructs a time-line that demonstrates the characteristics and changes in computers from 1946 to the present.

   3. The student constructs a collage depicting the history of computers.

   4. The student traces the history of another piece of equipment whose development compares with that of the computer demonstrating the previously taught factors.

   Some computer developmental characteristics follow:

   1. Changed from large, bulky equipment to compact parts and facilities

   2. Developed capacity of completing more complex jobs in a shorter length of time

   3. Increased storage capacity

The students will be taught a simple original programming language which illustrates the various functions of the computer. The activities of this course do not require a computer terminal.

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Dissemination and Staff Development

Contributors:
ALEX DUNN
THOMAS E. ROBINSON

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IV. DISSEMINATION AND STAFF DEVELOPMENT

A. DISSEMINATION

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Distribution of Program Documents

Dissemination during 1971-1974 continued to be an ongoing and continuous activity of the program's total operation. With the publication of the *Title III Final Report*, approximately 900 copies were distributed to educators and computer installations throughout the U.S.A. and abroad. This wide circulation has, in return, provided the program with an exchange of information from both foreign and domestic computer users, supplying valuable insight, feedback, and information about computer-assisted and computer-managed instruction. Membership in professional organizations such as Association for the Development of Computer Based Instructional Systems (ADCIS), National Association of Users of Computer Applications to Learning (NAUCAL), Association for Educational Data Systems (AEDS), the Maryland State Teachers Association (MSTA), National Council of Teachers of Mathematics (NCTM), and National Council of Teachers of English (NCTE) has also furnished staff members with an exchange of ideas and research data in the area of instructional and computer technology. Additional dissemination has been made through the publication of articles and research abstracts in educational and professional journals.

Seminars and Demonstrations

Serving as consultants, staff members made presentations at various universities, computer workshops, and educationally oriented seminars. Regular monthly visiting hours also were initiated during 1971-1973 to inform local citizens, school personnel, and visitors about the CAI Program's activities, its history and objectives. This monthly demonstration occurs at the program offices where the scope of innovative activities in progress is presented in a slide and tape presentation. The presentation is followed by a tour of the computer facilities and a hands-on demonstration of the IBM 510 Instructional Display. More than 700 visitors representing both foreign and domestic computer users have attended these sessions since June 30, 1971. Some of the vistors have included representatives from the following colleges and universities, corporations, school districts, and foreign countries:

Gettysburg College	Georgetown University
University of Maryland	State University of New York
Charles County Community College	Gallaudet College
University of Michigan	Medical University of South Carolina
University of Virginia	George Washington University
Mississippi State College for Women	Goucher College
Cornell University	Pennsylvania State University

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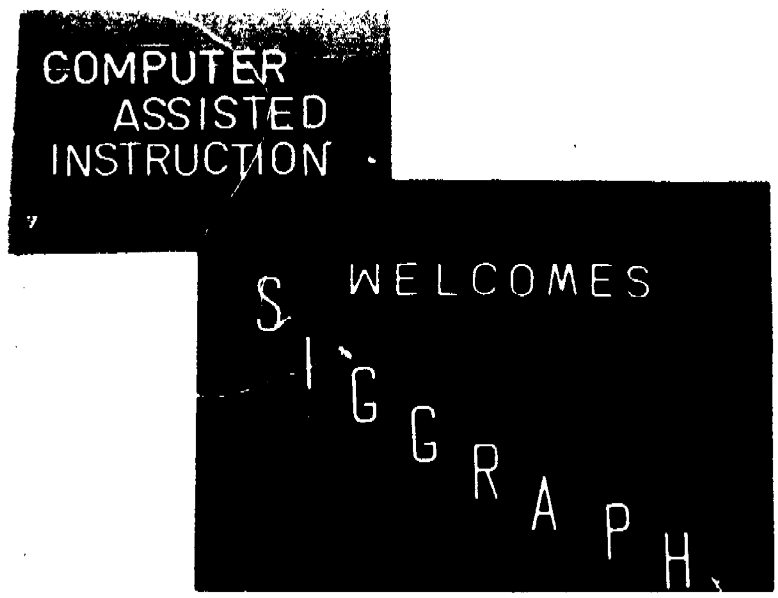
University of Liege, Belguim
Catholic University of America
University of Toronto
Ohio State University
Towson State College
American University
Montgomery College
Prince George's Community College
Glasgow Educational Corporation,
  Glasgow, Scotland
United Kingdom World Trade
Houghton, Mifflin Company
Eastman Kodak
UNIVAC
State Department of Education,
  Division of Vocational Rehabilitation
Anne Arundel County
Pittsburg Public Schools
Baltimore City Public Schools
North Carolina State Board of Education
XEROX
IBM
Academy for Educational Development – Inc.
MITRE Corporation
Institute for Advanced Technology
ENTELEK Inc.
Metropolitan Life Insurance Company
Data Designs Laboratory
Denmark
Switzerland
Germany
Rotterdam, The Netherlands
France
Tokyo, Japan
Saigon, Vietnam
United States Information Agency
U.S. Department of Commerce
United States Army Signal Center and School
NASA
Naval Medical Training

Another project document *Authoring Individualized Learning Modules: A Teacher Training Manual* has been distributed widely among colleges, universities, and teacher training seminars. This popular manual, which is designed to orient and train authors of CAI/CMI materials, details plans for developing self-instructional packages using a systems approach to learning. More than 300 copies have been distributed to educators and computer installations since June 30, 1971.



In an effort to inform as many educators as possible about the CAI/CMI operations, the program frequently serves as host to a variety of interested organizations. Most of the visiting organizations such as SIGRAPH (Special Interest Group in Computer Graphics) are educationally/technologically oriented.

Extensive use also has been made of CAI flyers describing the IBM 1500 Instructional System, the steps in curriculum development, and the modular instructional packages developed by teacher design teams at the program. These materials are available upon request from the program office.

Published Articles and Research

Articles relating to the program's operation, on-going research, and its use of the computer in the instructional process have appeared in various educational journals during 1971-1974. "The Computer As a Classroom Tool," co-authored by Mrs. Catherine E. Morgan and Dr. William M. Richardson, was published in the October, 1972, edition of *Educational Technology.* Thomas E. Robinson's comments and observations on The New Basic System were printed in the Association of Computing Machinery

(ACM) *SIGCUE* (Special Interest Group for Computer Uses in Education) Bulletin, April, 1972. The article was titled "Comments on Teacher/Student Authored CAI Using the New Basic System." Two abstracts also contributed by Mr. Robinson appeared in separate issues of the *CAI Reporter.* "Measuring CAI Effectiveness in Algebra II," an abstract documenting results of an Algebra II study, was published in the December, 1971, issue; in addition, the abstracted evaluation of student attitudes toward CAI appeared in the January, 1972, *CAI Reporter.* In May, 1974, an article co-authored by Alex Dunn and Mrs. Catherine E. Morgan was published in the *Audiovisual Instruction.* This article described the ways in which computer-assisted and computer-managed instruction support individualization at the three county schools. As this document goes to press, additional articles have been submitted for dissemination and are being considered for publication by other educational periodicals.

B. STAFF DEVELOPMENT

CAI Specialists

Changes in personnel during 1971-1972 required that several new staff members receive training on an informal basis after their initial employment with the CAI Program. Such training in most cases was a continuous and ongoing process provided by the director and other staff members for CAI specialists who had not participated in a formal teacher training workshop.

In October, 1971, Alex Dunn, an eleventh grade English teacher at the CAI Program High School was identified as a CAI specialist. Mr. Dunn, who earned his masters of arts degree at the University of North Carolina, had eleven years teaching experience (grades seven through eleven) as well as a variety of journalistic assignments prior to joining the CAI staff. His responsibilities at the CAI Program were to organize an English design team responsible for developing CAI curriculum and to prepare and edit all program publications. This position had been previously held by B. Jean Wastler who took academic leave to pursue a doctorate at the University of Maryland. Mr. Dunn participated in the 1971-1972 Teacher Training Program, attended a computer-assisted instruction seminar at Control Data Corporation, and later attended the National Council of Teachers of English (NCTE) preconvention workshop "Research, Evaluation, and Accountability for Teachers of English." He received additional training at other NCTE seminars such as the "Technological Innovations and the Teaching of English Symposium" and "The Famous Teachers' School, Secondary School English Conference." Much training, however, was provided informally by CAI staff members.

Both English and reading were other areas of curriculum that came under consideration in the fall of 1971. Katherine Dooner, a former elementary teacher enrolled in a doctoral program at Catholic University. also joined the staff in October of that year to develop a reading program. She was unable to complete her assignment and resigned in September, 1972. Subsequently, the part-time position in elementary reading was accepted by Anne Tipton, a former MCPS elementary reacher and instructional material specialist for NEA's Project LIFE (Language Improvement to Facilitate Education). Miss Tipton's experience include 12 1/2 years of classroom teaching (nursery school through fifth grade) and two years experience as instructional materials designer. Another staff change occured in November, 1971, when Susan Morgan, who had worked as a programmer, joined the professional staff to design and conduct evaluation studies. She was knowledgeable about the program's operation, and her prior experience in teaching, research, and programming provided valuable training for her new position as a CAI specialist in research. In September, 1972, Miss Morgan accepted a full-time research position at Hostos Community College in New York City. Her vacancy on the staff was filled by Grace Mullen in November, 1972. Before coming to the program, Mrs. Mullen, whose academic training was in the fields of research and psychology, had worked as a research assistant at McGill University. Her previous experience also included work with handicapped children. Staff members provided both Mrs. Mullen and Miss Tipton orientation and informal training.

In September, 1973, Thomas E. Robinson, CAI Specialist in charge of secondary mathematics and the Time-Sharing Project, received a fellowship for post-graduate studies at the University of Maryland. Consequently, he resigned the CAI specialist position he had held for 2½ years and was placed on professional leave. His position was filled in April, 1974, by John L. Randall, a mathematics teacher at Walter Johnson High School. Mr. Randall, who had eleven years experience as a classroom teacher, served on the CAI Advisory Council before joining the staff. He earned both his bachelor of science and master of science degrees at the University of Kansas, and acquired extensive experience in teaching a variety of mathematics courses including computer programming at the high school level.

In March, 1974, Robert Pokras joined the program to assume the duties of CAI Specialist in research. Mr. Pokras, a teaching assistant in the Department of Measurements and Statastics at the University of Maryland, also earned his bachelor of science degree in psychology at the university. Before coming to the CAI Program, he worked part-time for 2½ years as a home instructor of emotionally disturbed children in Prince George's County, Maryland.

It should be noted that training, a vital function of the CAI Program, has involved practically all staff members at one time or another. Such a process has provided the Program with CAI specialists capable of developing high quality curriculum, suitable for the students the computer serves. In addition, this training also has provided the program with a reservoir of educational technologists, skilled in curriculum development and well informed about the feasibility and implementation of CAI and CMI into existing MCPS curriculum. The fact that most staff members are experienced classroom teachers has contributed to the overall effectiveness of the training program. In fact, a learner-oriented philosophy has consistently remained the all-absorbing focus of the program since its inception in 1968. Pursuant to this purpose, it has been the philosophy of the program to do consistently what was considered best for the *student* whenever decisions were made. In the continuing search for effective methods designed to improve the total teacher training program, staff members have sought through questionnaires, individual conferences, and feedback from workshop participants to solicit information on methods of improving the training processes. A copy of one such evaluation form used at the completion of the CAI Training Program (IT-02), 1971-1972, is included in the Appendix of this report.

Teacher Training Program

Early in October, 1971, a year-long supporting teaching training program was initiated with 16 MCPS teachers. The selected teachers came from various elementary, junior high, and senior high schools throughout the county and represented a cross-section of academic and teaching backgrounds. Released time from classroom duties was provided all participants one day every two weeks for training in educational technology and the design and development of modular instructional programs. The stated objectives of the course were:

1. Participants will demonstrate a basic knowledge of computer fundamentals, computer-assisted instruction, and the IBM 1500 System.

2. Participants, using the systems approach to educational technology to aid in the individualization of instruction, will design and develop a single-concept instructional package and will identify the media to be used.

Five elementary, four junior high, and seven high school teachers met for a total of 110 clock hours from October 28, 1971, through May 25, 1972, and designed instructional packages reflecting their individual interests and academic training.

The following list details the authors and programs that were developed:

Supporting Teacher Training Program
1971-1972

Teacher	Modular Instructional Package
Barbara Blonder	ROOT WORDS AND PREFIXES
Jean Coxe	ALGEBRAIC FRACTIONS
Muriel Dahlberg	READING SECTION OF NEWPORT DEMONSTRATION
Ruth Eckard	ADDITION OF INTEGERS
[1] Cary Frey	A.C. SERIES IMPEDANCE CALCULATIONS
Robert Gallagher	[2] COMMA PUNCTUATION IN RESTRICTIVE AND NONRESTRICTIVE PHRASES AND CLAUSES
[1] Donna Gullickson	[2] ELEMENTARY MATHEMATICS PROBLEM SOLVING
[1] Linda Haupt	BEGINNING PHONICS SOUNDS
James Hough	BINARY CODED DECIMAL
[1] Thomas Kautz	SOLVING TRIANGLES – THE LAW OF SINES
Phyllis Ramsey	[2] A PROGRAM FOR TEACHING VERTICAL AND HORIZONTAL CENTERING IN TYPEWRITING, USING THE MATHEMATICAL METHOD
[1] Mary Schneck	[2] FRENCH RELATIVE PRONOUNS *QUI, QUE, LEQUEL, DONT*
Susan Silverman	CLASSIFICATION OF NOUNS
[1] Laura Stoskin	[2] LEAST COMMON MULTIPLE
Elissa Weinroth	CONSTRUCTING PLURALS FROM COMMON NOUNS
William Welsh	QUADRATIC EQUATIONS AND THEIR SOLUTIONS

[1] Supporting teachers who were invited to join design teams.
[2] Packages that were begun during the Supporting Teacher Training Program and continued under development.

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The supporting teacher program was validated during May, 1972, with a staff constructed posttest. Stated criteria for meeting validation standard was "80 per cent of the participants will master 80 per cent of the total objectives." Scores from the posttest showed that 81 per cent of the participants made an average of 80.3 on the objectives.

During the summer of 1972, an in-service course "IT-05 Educational Technology and CAI" was conducted under the aegis of the CAI Program to familiarize MCPS teachers with the basic concepts of educational technology, computer-assisted instruction, and individualized instruction. The six-week course, conducted by John M. Boblick, Cary Frey, and B. Jean Wastler, provided training in instructional technology and the design and development of CAI materials. Each of the 15 participants designed and developed a single concept instructional package for classroom use, employing the systems approach to aid in the individualization of instruction. For most teachers the six-hour credit course offered an initial opportunity to develop a learning module relative to their respective field of interest. Learning modules were developed in the areas of English literature, elementary math, U.S. history, geometry, trigonometry, algebra, consumer math, business, chemistry, and earth science.

User Training

Essential to the use of a new technology is the training necessary for its implementation. Experience has demonstrated that computer-assisted instruction in MCPS must be integrated with classroom instruction. Teachers must perceive this support as an important part of their regular instruction with students gaining in achievement and self concept through the use of CAI materials.

In this connection, users of CAI materials participate in work shops conducted by the CAI staff. Although users do not need experience in developing instructional materials, they must be completely informed about the design of each module that their students will be using. Therefore, these courses include intensive instruction relative to each package. The terminal, entering and enabling objectives, the interrelationships of these objectives, the criterion items, and the strategies employed are described and discussed. This instruction is followed by interaction with the programs at the terminals in the same way as their students. Manuals are provided which document all aspects of the programs, including sample individual student print-outs. Techniques for utilizing this computer information for subsequent small-group or individual instruction are described and discussed. In addition, information about the background, past experiences, research results, and future possibilities for CAI are provided, since teachers and administrators disseminate much of the informal information to parents and other citizens.

The above format has been used with the faculties of three involved schools and Rock Terrace High School.

Travel

Traveling by CAI Program staff members has been undertaken for staff development purposes (attending conferences, seminars, and workshops) and dissemination purposes (visiting other CAI installations, delivering papers, and conducting seminars).

For any on-going CAI installation to function effectively and experience optimum growth, it is essential that its staff be kept informed on the "state of the art." Staff members must remain knowledgeable and informed on new developments in hardware, software, and courseware. To see one of the first PLATO IV terminals and discuss its capabilities with Dr. Donald Bitzer, Superintendent Homer Elseroad, Dr. James Jacobs, Dr. William Richardson, and Mrs. Catherine Morgan visited the University of Illinois and the Magnovox Company in July, 1971, This meeting resulted in the CAI Program receiving a PLATO IV terminal in March, 1973.

Under the auspices of the Control Data Corporation, a two-day workshop on computer-assisted instruction was held from November 17 through 19, 1972, in Silver Spring, Maryland. Alex Dunn attended this workshop as part of his CAI training in becoming familar with CAI and CMI applications. The workshop provided information on different systems designs, CAI cost justification, various computer languages, and the future impact of CAI and CMI in educational systems.

Dr. William Richardson and Beverly J. Sangston attended the Association for Educational Data Systems (AEDS) Conference in Minneapolis during May, 1972, where they gave individual presentations on "Development of CAI Curriculum in MCPS." In April, 1973, Miss Sangston chaired and co-ordinated activities of the preconvention workshop "Instructional Uses of the Computer" of NAUCAL (National Association of Users of Computer Applications to Learning) which met in New Orleans.

During October 18-22, 1972, Thomas Robinson visited four northeastern educational institutions in which computer-assisted instruction was operational. These institutions were The National Technical Institute for the Deaf (Rochester, New York), Dartmouth College (Hanover, New Hampshire), The Poughkeepsie Day School (Poughkeepsie, New York), and Fairfield University (Fairfield, Connetticut). The primary objective of this trip was to look closely at those institutions which offer curriculum requiring computer support to elementary, secondary, and college students.

A fundamental concern related to the planning for expansion efforts in MCPS has been that of administration and staff training involved in such a large public school system. The Chicago Public Schools, having successfully implemented computer-assisted instruction extensively into its system, was considered a primary source of valuable information for the CAI Program. On June 5 and 6, 1973, Mr. Robinson visited the Chicago Public School System and interviewed Dr. Harry Strasburg, assistant superintendent, Department of Systems Analysis and Data Processing, and also Miss Rita Cooney, director, Computer-Assisted Instruction. Both educators provided valuable information relative to the implementation of instruction requiring student-computer terminal interaction.

It was observed that the administrative functions of the Chicago Public Schools are handled with the assistance of an IBM 370/155 System. The Department of Computer Education likewise makes use of this system by application of 30 IBM 1050 remote student stations. This usage takes the form primarily of data processing for computer science courses and student programming for problem solving applications. The Department of Computer-Assisted Instruction uses computer support provided by a UNIVAC 418 time-sharing system. Seven Title I elementary schools are each equipped with 15 UNISCOPE 100 CRT terminals with 14 additional schools scheduled to receive terminals during the next school year. Each day students in the upper grades received ten minutes of drill and practice in reading and another ten minutes of either mathematics or language arts. The curriculum in use was purchased from Computer Curriculum Corporation of Palo Alto, California.

In November, 1972, the National Council of Teachers of English, meeting in Minneapolis offered a three-day preconvention workshop on "Research, Evaluation, and Accountability for English Teachers." Alex Dunn, English design team leader, attended the workshop to:

1. Participate in discussions on current research, evaluation, and accountability

2. Exchange ideas with other English teachers writing objectives in the affective domain

3. Determine the "state of the arts" at the national level in areas of

a) Technology as related to English

b) Student monitoring in English

c) Individualization in English

Five preconference groups examined such topics as (1) English behavioral objectives; (2) monitoring student progress; (3) research, design, and evaluation of English modules; (4) accountability; (5) and the individualization of the instructional process.

Hardware Configurations, Facilities and Technical Operations

Contributor:
JAMES R. ESHLEMAN

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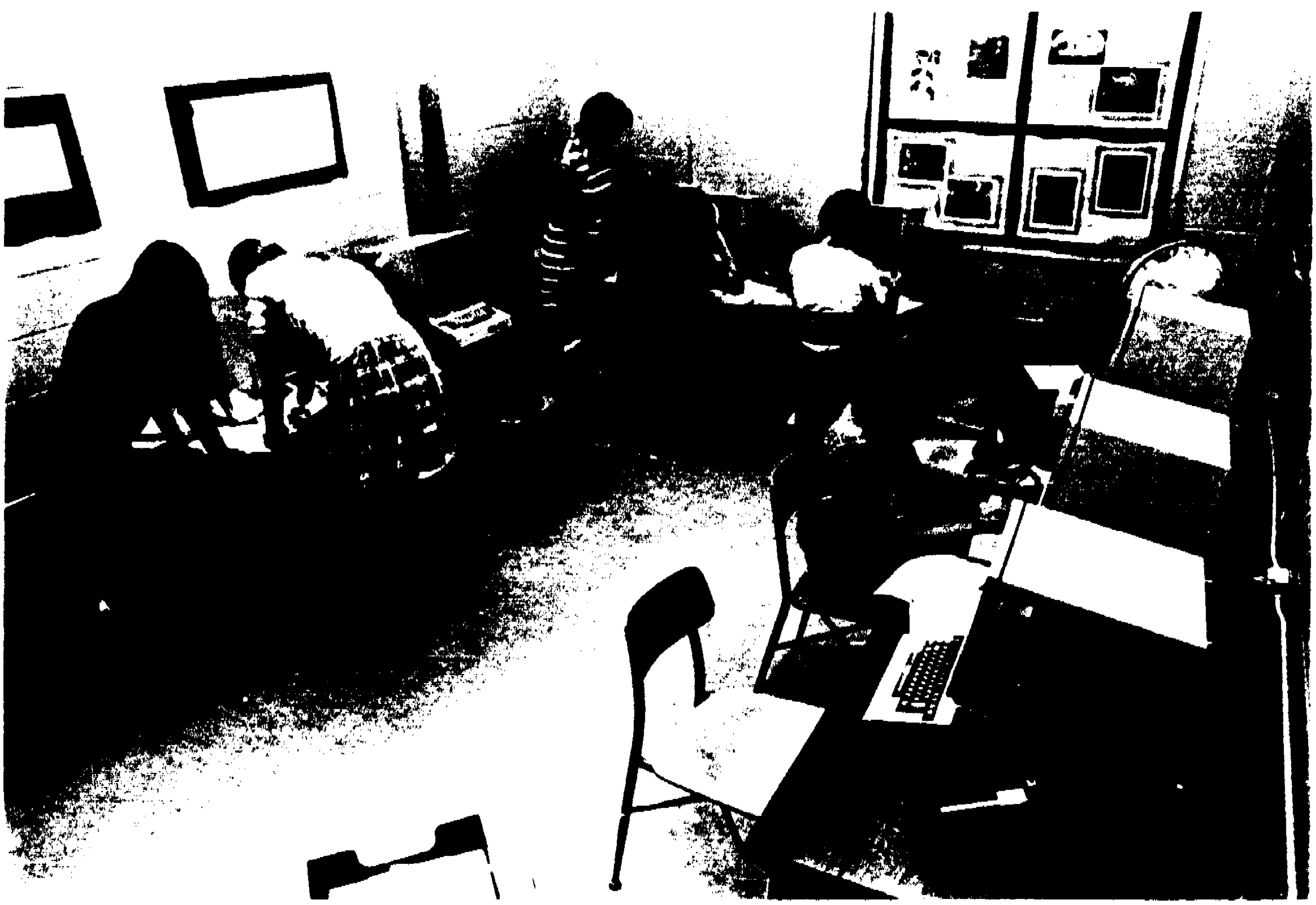
V. HARDWARE CONFIGURATIONS, FACILITIES, AND TECHNICAL OPERATIONS

CABLE INSTALLATIONS

Newport Junior High

During the spring of 1972, seven remote student terminals and one proctor typewriter were installed in Newport Junior High School. Installation of the student terminals was initially planned to be done completely by MCPS personnel, thus saving a considerable amount of money and time. However, it was later determined by the Department of Maintenance that the job of cable installation was too involved to be done internally. In late November, 1971, specifications were prepared and bids were invited. The contract was awarded to Electric Service Company, Arlington, Virginia, the same company which had installed the Pleasant View cables in 1969. Work began on the 900-foot cable installation in late April, 1972, with the digging of a 450-foot trench between Einstein and Newport.



In September, 1972, Newport Junior High School became the third school to house multi-media stations. A small room was converted to a computer terminal room with seven student stations, one typewriter terminal and telephone.

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These cables were installed in a slightly different manner from those in Pleasant View in the hopes that potential lightning damage could be minimized. As of this date, these changes seem to be beneficial since there has been only a small amount of lightning damage to the student terminals. The changes included burying the cable so that no part would be closer to the surface than 30 inches. A minimum spacing of four inches was also maintained between each of the two computer cables and the group of coaxial cables. Lightning suppression boxes also were attached to the coaxial cables in Newport Junior High. The methods used to bring the cables into the two schools also was changed considerably. In the Pleasant View installation, the cables entered both Einstein and Pleasant View from above ground. In the Newport installation, the cable entered each school below ground-level to provide more security as well as a less attractive target for lightning.

An IBM customer engineer was present during the installation to test the cables prior to refilling the trench. It was discovered at this time that one coaxial cable was shorted and unusable. A decision was made to cut the shorted cable in half and use the functional 450-foot section in the underground span, thus allowing work to proceed. Later two pieces were spliced to the cable, restoring its original length.

Both Einstein and Newport have suspended ceilings which greatly facilitated the installation of the cables within the schools. A metal tray was installed above the suspended ceilings to carry the cables to the computer room in Einstein and to the terminal room in Newport. Sheet metal cable enclosures also were installed in both schools wherever the cables were exposed in a classroom.

Since the IBM 1500 System can support only a total cable length of approximately 2000 feet, it was necessary to install a feature that would allow either Pleasant View or Newport to be disconnected. Electric Service Company installed connectors on the two computer cables in the computer room to disconnect Newport and connectors in the Mathematics Laboratory at Einstein to disconnect Pleasant View. These connectors soon proved to be difficult to operate and generally unsatisfactory for the repeated use they received. Therefore, quick latching connectors were installed in both locations. These connectors have been completely satisfactory in both ease of operation and reliability.

Pleasant View Elementary

In August, 1972, two student terminals were installed in a first grade classroom at Pleasant View Elementary. Since this room is adjacent to the present computer terminal room in Pleasant View, it was a simple matter to move two CRT terminals and audio units from one room to the other. A small hole was chipped through the common wall and the cables fed through to the terminals. A sheet metal cable enclosure was installed to protect the cables in the first grade classroom.

Parent aide Angela Day checks student records before "entering" individual student prescriptions for the day.

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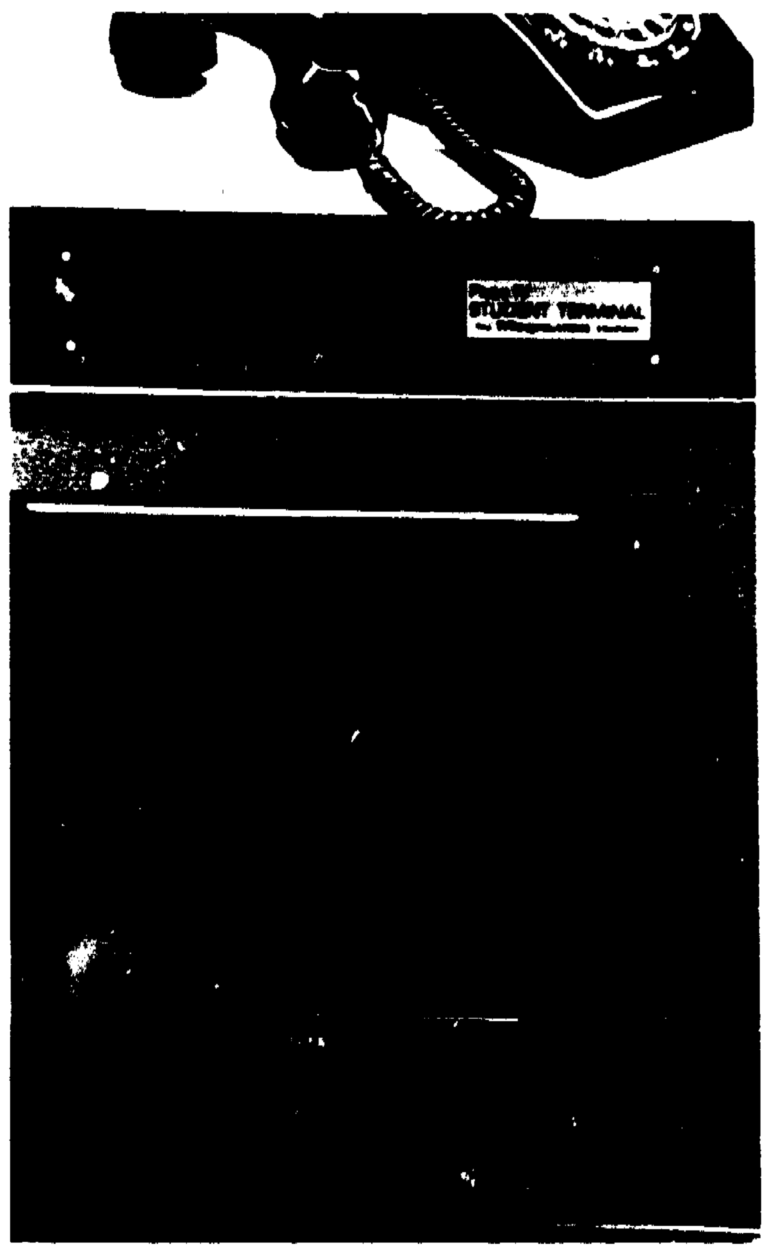
IBM 1500

At the present time, there are 26 student terminals located in four classrooms in three different schools. Two terminals are situated in the computer room for programming and background purposes. There are eight student terminals and one proctor typewriter in Pleasant View Elementary School. Two of these terminals with audio units are used in a first grade classroom, and the remainder are located in the computer terminal room. Seven student terminals and one proctor typewriter have been placed in Newport Junior High. Einstein High School houses eight student terminals and one proctor typewriter in the Mathematics Laboratory, while three student terminals with image projectors and audio units are located in a room adjacent to the Instructional Media Center (IMC). These terminals are used in the CARE 1 program for teacher training purposes.

Plato IV

In March, 1973, a PLATO IV student terminal was installed in the IMC at Einstein High School. This terminal is connected to a CDC computer at the University of Illinois at Champaigne–Urbana. Unlike the IBM 1500 System which requires special cables to connect the terminals to the computer, the PLATO terminal uses a dial-up-phone line. There was very little advance preparation necessary for the installation of the PLATO terminal other than having the telephone company install a telephone and a data coupler.



FACILITIES

Newport Junior High School

A large storage room in the science wing of Newport Junior High School was modified as the CAI terminal room. A separate lighting and wiring system was installed as well as sheet metal covers for the cables and station connector boxes. Since there is no central air-conditioning at Newport and the terminal room is situated in an area where ventilation is poor, there has been a problem of heat accumulation.

Pleasant View Elementary

The first grade classroom at Pleasant View Elementary required only two modifications: the addition of two duplex outlets to provide power for the terminals and the addition of sheet metal cable enclosures to protect the computer and coaxial cables.

MALFUNCTIONS

Computer Room Air-Conditioner

The air-conditioning unit which cools the central computer room has become inoperative several times in the last two years. Such malfunctions cause operation of the IBM 1500 Instructional System to cease. Theoretically, the system will operate in temperatures up to 90°, but the tolerance of this particular system is much less. When the temperature reaches 76°, the system ceases to function properly. For future considerations, it is highly recommended that an alternate source of air-conditioning be provided.

Lightning

Damage as a result of lightning has largely been eliminated through the use of lightning suppression boxes designed by IBM. The staff, nonetheless, disconnects both the computer cables and the coaxial cables if a severe thunderstorm is expected.

Short Circuit in Electric Line

During the March 5, 1973, session of CARE 1 in the IMC at Einstein, a short circuit occurred in the 110-volt outlet strip. The short circuit was caused by a loose outlet coming into contact with the conduit. This caused 110 volts to flow through the ground circuit to other terminals as well as to the central computer. Extensive damage was caused to all terminals connected to the system by either the computer cable or the coaxial cables. Approximately two weeks were required to repair the damage before all classes could resume normal on-line interaction.

Severing of Computer Cables to Pleasant View

In August, 1972, the Department of Maintenance, while digging a drainage trench on the school property, accidentally severed all of the computer and coaxial cables leading to Pleasant View Elementary. Unfortunately, the break in the cables occurred at a place where a large amount of water was present in the soil. Several days of rain after the cables were cut prevented repairs and also allowed a considerable amount of water to enter the cables. The cables were spliced in early September and the student terminals were ready for use by September 11. The terminals were operative for one week when the light pens and video quality deteriorated to the point that students could no longer use the terminals. It was assumed that moisture had entered the cables at the splices, resulting in a short circuit. The Department of Maintenance respliced all of the cables, and students could again use the terminals on October 11. The cables remained usable for several months; then in early December, the first of several cables started to fail. By mid January, all but two terminals were unusable. The Department of Maintenance again inspected the cables and determined that water, which had entered the cables shortly after the initial break, was causing the short. Prior to resplicing the cables, a vacuum pump was used to draw out accumulated water. Nearly a gallon of water was pumped from the 16 coaxial cables. Since the drying and resplicing in February, the technical operations have continued uninterrupted and without difficulties. It is now felt that a large amount of water entered the cables immediately after the initial break instead of gradually seeping through the plastic covering as was earlier believed.

5. Viking Audio Tape Duplicator

Prior to the development of the elementary READING, ARITHMETIC, and PHONICS PROGRAM (RAP), little use was made of the Viking Tape Duplicator. While attempting to duplicate the audio tapes for RAP, it became apparent that there was a problem with the reproduction of the address track. Since a maintenance contract had not been obtained from IBM when the equipment was originally purchased, a request was made to the school system's Division of Engineering for repairs to the unit. This department lacked the necessary equipment, so it was later referred to an IBM customer engineer for repairs.

TECHNICAL OPERATIONS

New Software

Financial Accounting

ACC72 and ACC73 are FORTRAN programs which provide management with information on allocations, disbursements, encumbrances, and unencumbered balances for the accounts used in FY 72 and FY 73 by the CAI Program.

PRBAL is a FORTRAN program which projects the balances remaining in the payroll accounts at the end of the fiscal year. The program takes into consideration employees' anniversary dates, promotions, terminations, the hiring of new employees, and the number of working days for ten-month personnel.

Other Programs

DICNG is an assembler language program which is used in modifying course programs received from other educational institutions. The program allows the use of existing dictionaries in the new courses, thus saving considerable core space.

LABEL is a FORTRAN program which prints address labels from the information provided by punched cards. The program also has the capability to selectively print certain labels depending on information supplied on the control cards.

Audio Tape Preparation

Preparation of the first grade READING, ARITHMETIC, and PHONICS PROGRAM (RAP) required additional programming and background support because of the program's heavy use of audio. A programmer must supply instructions to position and play the audio tape for a given length of time. The computer operator prepares the student tape cartridges by following a rather complicated three-phase process. The first phase, called the preprocessing phase, consists of a selected person recording the messages in a sound proof studio, generating an audio symbol table, and initializing an IBM 1506 tape cartridge. The second phase, the assembly phase, combines the three products of phase one to form a master cartridge containing both track addresses and audio messages. The symbol table, created in phase one, is also updated with the appropriate addresses of each message. Phase three, the postprocessing phase, consists of duplicating the master cartridge to create student cartridges and running the address substitution program which places the proper address information in the COURSEWRITER instructions.

Program Plans

The following Program Plans were submitted to the Montgomery County Board of Education for adoption in the FY 75 Budget.

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VI. PROGRAM PLANS

The following Program Plans were submitted to the Montgomery County Board of Education for adoption in the FY 75 Budget. Recommendations 1, 2, 3 and 5 were accepted and approved for implementation as described herein.

This paper describes the plans of the Computer-Assisted Instruction (CAI) Program for the Fiscal Years 1975-1976. Based on the experience of five years and the results of evaluation studies, five recommendations are made, followed by the justification for each. The resource requirements for the first three recommendations are included with these plans.

Although it is anticipated that CAI will be economically feasible for widespread utilization within three to five years, it must be understood that with the existing IBM 1500 CAI System or the proposed IBM 370 System CAI is not currently economically feasible for all students. Therefore, the use of this technology should be limited to instruction for those students for whom the significant achievement gains justify the expenditure of extra dollars. To be specific, it is recommended that CAI be provided to those students who are achieving below grade level, to special education students, to those situations where increased class sizes can help displace hardware costs, or to computer education courses and problem solving situations which require computer support.

The three major thrusts of the CAI Program plans for Fiscal Years 1975-1976 are:

1. To meet better the needs of special groups of students in MCPS by increasing their achievement in mathematics

2. To replicate the evaluation data collected to date by expanding into 20 schools so that when computer hardware costs are substantially reduced in 3-5 years CAI services can be expanded to instruction for all categories of students

3. To provide the necessary computer support for program and problem solving in secondary schools

RECOMMENDATION NO. 1

Three validated CAI arithmetic packages will be provided to students achieving one or more years below grade level in 13 elementary schools (12 new elementary schools plus Pleasant View). Selection of schools will be based upon current pupil appraisal data.

CAI arithmetic materials will be provided to underachieving students based upon the following predictions:

a) That the achievement of at least 90 per cent of the underachieving students using the CAI programs will be at or above grade level in arithmetic within two years. This means that a child entering the fourth grade, one grade level behind, will enter the sixth grade at or above grade level in arithmetic skills. The total two-year cost per student will be $236. This amount will provide the student with CAI for a one-half hour period for each week for two years at a cost of $6.55 per hour which covers computer, staff, communications, and all other program costs.

As computer equipment and instructional terminal costs are projected to decrease dramatically within the next five years, the cost for improved arithmetic achievement should be reduced from $236 to $72 or less per student for a similar two-year period by 1978.

b) That arithmetic achievement for students in special education will be substantially increased above expectancy. It is predicted that 80 per cent of these students will achieve an increase in arithmetic skills of one grade level per school year. The cost for this achievement is $118 per student per year. which will provide one-half hour per week of CAI.

By 1978, it is projected that similar results can be obtained for special education students for $36 per year.

Justification

The above projections are supported by evaluation data collected at the CAI Program. The 1971-1972 sixth grade study showed significantly greater achievement through CAI than by traditional instruction. A retention study conducted in the fall showed that these significant gains were maintained. In addition, using the ITBS arithmetic scores given in October, 1972, showed the CAI students with a mean grade score of 7.52 and the control students with a mean grade score of 7.02. A 1972-1973 fourth grade study showed that CAI students made an average gain of [illegible].7 months in 4 months as compared with the control students' mean gains of 4.5 months. An examination of the low halves showed the CAI group making a mean gain of 5.74 in raw score as compared with the control with a mean gain of 2.68 in raw score. All of the above CAI students received CAI 30 minutes per week. Table 1 contains summaries of these studies.

During the past three school years, students from Rock Terrace High School have used the CAI arithmetic programs at Einstein High School. The average gain for these students during the 1971-1972 school year was 7.6 months after 40-50 minutes of CAI use per week during a four-month period. During the 1972-1973 school year, Rock Terrace students made a mean gain of one year in arithmetic achievement using CAI for an average of only 17.8 hours. National studies which have been conducted with mentally retarded adolescents show that achievement in the basic skills is difficult to maintain and increased achievement is rare. Special education students whose basic skills are improved will be able to perform simple clerical tasks and, therefore, increase the possibilities of their securing gainful employment.

The first Goal of Education[1] is to develop programs that enable each child to acquire those skills basic to all learning. The ability to perform mathematical computations is listed as a basic skill. In the same document, a commitment is made to adopt new and different approaches when it is determined that they will contribute more effectively to the fulfillment of the goals.

The use of the CAI arithmetic packages is strongly recommended for students in regular classrooms who are achieving below grade level and for students in special education programs. The optimum time for the development and building of basic arithmetic skills is during the elementary school years.

[1] Revised Statement of the Goals of Education, Office of the Superintendent of Schools, MCPS, January 9, 1973.

Since these skills are sequentially interrelated, any lengthy delay in acquiring those which are prerequisite to more advanced skills may preclude the latter from ever being learned. A student, for example, must be able to subtract and multiply whole numbers accurately before he can learn to divide using these numbers. Individualization is obviously impractical for most instruction; and without the supports of diagnostic instruments and extensive related instructional materials for teachers, many students do not gain the basic skills essential to their vocational and avocational objectives.

Twelve schools are recommended so that an evaluatic CAI can be made following its use with a wide variety of students from different geographical sections of the county and with different backgrounds and reasons for their low achievement levels. One or more of the schools to be selected may be a school for students in special education.

One computer terminal will provide a one-half hour CAI experience per week to each of 60 students. As shown in the controlled sixth grade study, student use for this period of time produced significantly greater achievement gains. Using the current computer equipment, 283 elementary students in the regular program and 58 in the elementary summer school program received approximately 2,000 hours of CAI during the 1972-1973 school year. The implementation of this recommendation will provide 3,360 students during the regular school year and 390 in the summer school programs for a total of 63,360 hours of CAI.

RECOMMENDATION NO. 2

One computer-managed (CMI) and ten computer-assisted (CAI) instructional packages in mathematics will be provided to seven secondary schools to include Einstein High School and Newport Junior High School, beginning in September, 1974. The two objectives for this recommendation are:

a) To provide greater individualization and personalization with equal or greater achievement at potentially lower cost. Classes with computer management support may have 40 per cent more students than classes without this technology.

b) To increase achievement for students who are underachieving

Justification

These computer support services will be provided based upon the following prediction:

That computer-managed geometry classes can be individualized. Class size can be increased by 40 per cent, and each student will receive significantly more individual attention from his teachers than in traditional classes. Students will achieve as well or better in traditional classes with average or underachieving students achieving above expectancy. Increasing the number of students in six classes will offset $7,200 of the $22,000 program costs per school.

With two nationally known computer hardware developers predicting a cost of 60-80 cents per terminal hour by 1978, the $22,000 terminal cost will be between $3,600 and $4,800 per year against a saving of $9,000 in teachers' salaries (assuming a 5 per cent per year salary increase). This would represent a net savings of between $700 and $900 per section of geometry per year.

CAI Program data support the above statements on individual attention and overall achievement. A doctoral study by an MCPS administrator provided the information relative to average students in CAI classes achieving above expectancy.

Data to support the increased achievement objective above also are contained in the results of an Algebra II study conducted during the first semester of the 1970-1971 school year and in an Algebra I study during the 1972-1973 school year. See Table 2 for summaries of the secondary research studies.

During the 1972-1973 school year, approximately 500 students at Einstein High School used the terminals for CAI/CMI instruction for 3,094 hours. Under this recommendation, student use of CAI/CMI programs in six senior high schools would be approximately 40,000 hours.

RECOMMENDATION NO. 3

The following four computer literacy mini-courses will be implemented in the schools with computer terminals:

Grade	Course	State of Development
K-1	COMPUTER AWARENESS	Pilot tested, spring, 1972 Validated, September, 1972
5	HOW A COMPUTER WORKS	Developed Pilot test
8	VOCATIONAL AND SOCIAL IMPLICATIONS OF COMPUTERS	Under development
9-12	COMPUTER LITERACY AND PROBLEM SOLVING	Time-sharing project to teach a programming language for problem solving was in eight secondary schools – 1972-73 school year and nine during the 1973-74 school year

The recommendations made by the Committee on Computer Education for the National Science Foundation[2] stress the need for at least one universal computer-literacy course for the secondary school.

Increased national and international emph[illegible] is being placed on computer technology; and, therefore, it is strongly recommended that all secondary schools be provided the support for computer literacy and programming language courses as soon as possible.

Justification

The foregoing recommendation is directly related to two MCPS Goals of Education:

1. SCIENTIFIC UNDERSTANDING – understanding of scientific advances and their part in modern technology

[2]Conference Board of the Mathematical Sciences, *Recommendations Regarding Computers in High School Education*, April, 1972.

2. CAREER DEVELOPMENT – knowledge and appreciation of the wide variety and interrelationship of occupations in modern society; and the knowledge, skill, and abilities that enable one to secure satisfying employment, embark upon further training and education in a chosen career field, and adapt occupational talents to changing job demands and opportunities

The Fiscal Year 1974 budget contains a $25,000 item for commercial time-sharing computer services for problem solving. Terminals, computer time and storage, communication costs, and supplies are provided to nine secondary schools for a total of 44 terminal months at a cost of $570 per month per school.

During the 1972-1973 school year, the commercial time-sharing services were provided to eight secondary schools. Each of these schools implemented computer science into selected mathematics courses; and students were instructed in BASIC, a computer language implemented in all major colleges and universities in the United States. Pupils then developed computer programs to solve mathematical, physical, and social science problems. A minimum course for this problem solving project has been defined as ten classroom instructional periods and two on-line computer hours for each pupil enrolled. The objectives and assessment materials have been developed jointly by the CAI Program and the Department of Curriculum and Instruction with input from school-based projects and classroom teachers.

If Recommendations 1 and 2 are implemented, the nine schools could have the same services on a year-long basis or 108 terminal months for $22,000, or a cost of $204 per month per school. In addition, any increase in the number of terminals would reduce the cost per month per school.

RECOMMENDATION NO. 4

Responsibility for all instructional uses of computers will be combined within one organizational component of Montgomery County Public Schools. This would include the following functions: computer literacy and education, vocational data processing, remote computing and problem solving, vocational information retrieval, and computer-assisted and computer-managed instruction.

Justification

Responsibilities for the various functions relating to the instructional uses of the computer are currently spread among three offices. In addition, a number of individual schools are interested in offering computer literacy courses and are developing course objectives. With the increased interest in the technology and the growing demand for the computer as both the subject of and an aid in a variety of academic instructional areas, greater systematic planning for and use of instructional computer facilities and staff could be obtained from a single organizational unit.

RECOMMENDATION NO. 5

The final recommendation is that outside funding will be actively sought for the development of computer-assisted and computer-managed instructional systems in reading, language arts, and English.

Justification

Proficiency in the basic skills of reading and composition is an important MCPS academic goal. Moreover, results from a recent survey conducted by the Vitro Corporation[3] for the Maryland State Department of Education showed that Maryland parents considered "mastery of reading skills" the most important educational goal.

The CAI research shows that student achievement in mathematics can be significantly increased through systematic curriculum design and computer support and that teachers can provide more individual attention to students in CAI and CMI classes. In addition, there is outside research to support the position that similar CAI/CMI development in reading, language, and English results in significant gains in achievement. However, work in these areas has been extremely limited. MCPS has capable instructional technologists who have demonstrated that they can develop and validate CAI/CMI curricula and conduct the required staff development activities to implement its use. It is further recommended that other disciplines be identified for future curriculum development.

RESOURCE REQUIREMENTS FOR RECOMMENDATIONS 1-3

The resources required to implement these recommendations include curriculum, computer equipment, staff, and space requirements. A description of each follows:

Curriculum

The validated CAI mathematics instructional packages were developed for use on the IBM 1500 Instructional System. This system is being provided to MCPS by the IBM Corporation lease-free from July 1, 1971, through June 30, 1974. As the 1500 System cannot be expanded beyond 32 student terminals, the curriculum will need to be recoded for use on other computer equipment. Forty-five thousand dollars ($45,000) has been designated in the Fiscal Year 1974 budget to provide the computer terminals and communications equipment which will be used for recoding the curriculum materials.

The curriculum for the secondary problem solving and computer literacy course has been developed. Available to each secondary school in the project are the objectives, assessment items, and instructional materials, as well as lists of textual and audio-visual reference materials suitable for junior and senior high school students. The mini-courses for elementary school use include the objectives, assessment items, and course outline. Following validation of the elementary courses, they will be made available to all county schools.

Computer Equipment

Computer equipment, which will support 91 visual terminals in 20 schools for CAI/CMI and nine on-line typewriter terminals in nine secondary schools for problem solving, can be provided by replacing the IBM 370/145 computer system now in use by the school system with an IBM 370/158 computer system which would provide both administrative and instructional computer services.

[3]Maryland State Department of Education, *Goals and Needs of Maryland Public Education*, 1972.

This will allow MCPS the opportunity to utilize the excess computer capability for administrative functions during periods of noninstructional uses (primarily 10 p.m. to 7 a.m. daily and nonschool days). Table 3 lists the costs of providing the computer equipment to support these plans.

As the kindergarten-first grade computer awareness course requires that each child use a computer terminal on only one occasion, this experience could be provided by the elementary schools with computer terminals. The implementation of the fifth and eighth grade computer literacy mini-courses does not require computer equipment. The costs of the terminals and communications for computer literacy and problem solving for the secondary schools are listed as a separate item in Table 3 and are included in the totals.

Staffing

Essential to the implementation of computer-assisted and computer-managed instructional systems is the integration into each school program. The CAI teachers will provide the necessary training in the concepts of instructional technology and continuing assistance during the year in the use of diagnostic, drill, and tutorial CAI and CMI materials for teachers for individualization. The articulation between the classroom teacher an ' the CAI program staff is essential if increased student achievement is to be replicated in new schools. In addition, the CAI teachers will provide training in computer programming and program solving for secondary teachers and will work closely with the math resource teachers in the implementation of geometry and algebra materials. Although the total number of positions to implement all three recommendations, as shown in Table 3, will remain at 12.5 for Fiscal Years 1975 and 1976, two additional CAI teacher specialists would be requested. The two teacher assistant positions would be eliminated as the computer terminals would be located in classrooms, mathematics laboratories, and instructional material centers.

Space Requirements

Since December, 1968, the computer and the CAI Program offices have been located at Albert Einstein High School; and there are terminal rooms at Einstein High School, Pleasant View Elementary School, and Newport Junior High School.

There is sufficient space at the Central Office for replacing the present computer equipment with an IBM 370/158.

As student terminals will be located in classrooms, libraries, or mathematics laboratories, no special terminal rooms in schools would be required.

Plan for Gradual Implementation During FY 1975

In order to provide the support anu training necessary to implement these plans, the acquisition of the new computer equipment will be delayed until January 1, 1975.

Fourteen instructional terminals will be connected to the IBM 370/145 System at Washington Center from July 1 through December 31, 1974. These terminals will provide continued instructional services to Pleasant View Elementary School and Einstein High School students, and four of the terminals will provide instructional stations for a training center for faculties who will be using the CAI/CMI curriculum during the school year 1974-1975. The new computer system with 30 student stations would be operational in January, 1975, with the 16 new terminals placed in one secondary and three elementary schools at that time for a total of 30 terminals. In February, the remaining 14 schools (five secondary, nine elementary) will receive terminals and begin student use in February. This last addition will bring the total terminals for CAI/CMI to 91.

The time sharing project for problem solving now in nine secondary schools will be continued using a commercial service for the first semester and connecting to the 370/158 system in February.

This phasing-in process will allow for in-depth training for school staffs in instructional technology and computer-assisted instruction. It will also provide the CAI Program staff with detailed information relative to curricula for which the revised instructional strategies are required and to its implementation with students. The gradual phase-in process will also allow for a second-semester evaluation of the expanded use of CAI.

TABLE 1
Summary – Studies Related To Recommendation No. 1

SIXTH GRADE – September, 1971 – May, 1972

Cooperative School and College Ability Test, Form 5A Mean Gains			
Item	N = 58 Total Group	N = 29 Low Halves	N = 29 High Halves
Control	3.54	5.38	2.34
CAI	5.19	6.93	3.59
t-score	2.81**	2.10*	3.23**

Criterion Referenced Test Mean Gains N = 53	
Control	4.09
CAI	5.88
t-score	2.35*

* $p < .05$
** $p < .01$

SEVENTH GRADE – Follow-up of above study – October, 1972

Iowa Test of Basic Skills[1] Grade Equivalent Means N = 46[2]	
Control	7.02
CAI	7.52

1. Subtest most closely related to CAI arithmetic modules
2. Forty-six of the 58 matched pairs in 1971-72 sixth grade study

TABLE 1 cont.

FOURTH GRADE – February – June, 1973
Mean CAI time 5.5 hours

Stanford Achievement Test – Arithmetic Computation Mean Gains		
Item	Control N = 76	CAI N = 67
Total Group Low Half High Half	2.91 2.68 3.13	5.35 5.74 5.00
Analysis of Variance on Ability Groups: F = 7.22**		

** p < .01

Grade Equivalent Means		
Pretest Posttest	4.11 4.56	4.19 4.96

ROCK TERRACE – 1971-72 (January-May, 1972)

Wide Range Achievement Tests – Arithmetic N = 10	
Pretest – Grade Equivalent Means	4.15
Posttest – Grade Equivalent Means	4.91
Mean Gain	.76
Range of Gains	3 months to 1.7 years
Mean CAI time	11.0 hours

1972-73 (November, 1972 – May, 1973)

Wide Range Achievement Tests – Arithmetic N = 8	
Pretest – Grade Equivalent Means	4.4
Posttest – Grade Equivalent Means	5.4
Mean Gain	1.0 year
Range of Gains	3 months to 3 years
Mean CAI time	17.8 hours

TABLE 2
Summary – Studies Related To Recommendation No. 2

INDIVIDUAL ATTENTION – February 28 – May 12, 1972

Mean Percentage of Total Teacher Time		
Definition	Control (3 Classes)	CAI (3 Classes)
I. Talking to one student – no one else listening, or listening to one student	26%	50%
II. I, or talking to one student within a group of six or less students	30%	69%
III. I, II, or talking to one student within a group of seven or more students	44%	71%
$X^2 = 33.12$**		

ALGEBRA II – September, 1970-January, 1971

Blyth Second-Year Algebra Test Results		
	Control (N=22)	CAI (N=22)
Pretest	14.82	14.73
Posttest	18.95	21.50
Mean Gain	4.14	6.77
$t = 2.32$*		

ALGEBRA I – September, 1972-June, 1973

Lankton First Year Algebra Test Raw Score Means				
	N	Pretest	Posttest	Posttest Stanine
Control	65	17.0	22.89	5
Einstein – Self Pacing Non-CAI	29	17.07	25.03	6
Einstein – Self Pacing with CAI	33	16.67	27.03	7
Analysis of Variance on Groups: $F = 7.50$**				

* $p < .05$
** $p < .01$

TABLE 2 cont.

GEOMETRY – September, 1971 – June, 1972
Cooperative Mathematics Test – Geometry Form B (Part I) Results

No significant differences in test results ($t = 1.23$ n.s.). CAI classes averaged 33 students while control classes averaged 23 students.

Complete reports of each of the above are available.

Appendix

ERIC

APPENDIX

CAI Program Staff

Director	Catherine E. Morgan
Secretary to the Director	May S. Sakai *Marcia S. Decker
CAI Specialists	*Kathryn A. Dooner Alex E. Dunn *Susan M. Morgan *Grace C. Mullen Robert Pokras John L. Randall *Thomas E. Robinson Beverly J. Sangston Anne Tipton
Technical Staff Supervisor	James R. Eshleman
Instructional Programmers	*Alan D. Ash David B. Barr Michael E. Dyson Harold L. Freeman *Peter J. McLellan William G. Swisher
Typist	Linda M. Intellini
Teacher Assistants	Patricia A. Cutlip Pleasant View Elementary Edith L. Gallogly Newport Junior High

*Terminated employment

Supporting Teachers
Design Teams
(1971-1974)

Elementary		*Schools*
Ann Cummins		Pleasant View Elementary School
Donna Gullickson	(1972-1973)	Pleasant View Elementary School
Linda Haupt	(1972)	Bradley Elementary School
Donna Kirsch		Farmland Elementary School
Laura Stoskin	(1972-1973)	Somerset Elementary School
Secondary Mathematics		
Margarita Escatell	(1972-1973)	Einstein High School
Karl Figert		Einstein High School
Thomas Kautz	(1972-1973)	Churchill High School
Ann Roger		Kensington Junior High School
Mary Weikel		Hoover Junior High School
Other		
English		
Robert Gallagher	(1972-1973)	Einstein High School
Anne Wolf	(1972-1973)	Parkland Junior High School
French		
Anne Dudley	(1971-1972)	Kensington Junior High School
Mary Schneck	(1972-1973)	Woodward High School
Industrial Arts		
Cary Frey	(1972-1973)	Magruder High School
Donald Konschnik		Einstein High School
Social Studies		
Dennis Cochran		Einstein High School
Jeffrey Schutz	(1971-1972)	Parkland Junior High School

Instructional Technology Course
Participants – 1971-1972

Name	*School*	*Level or Subject*
Barbara Blonder	Rock Creek Palisades	Elementary
Jean Coxe	Newport Junior High	Mathematics
Muriel Dahlberg	Newport Junior High	Reading
Ruth Eckard	Newport Junior High	Mathematics
Cary Frey	Magruder High	Industrial Arts
Robert Gallagher	Einstein High	English
Donna Gullickson	Pleasant View	Elementary
Linda Haupt	Bradley Elementary	Kindergarten
James Hough	Einstein High	Data Processing
Thomas Kautz	Winston Churchill High	Mathematics
Phyllis Ramsey	Einstein High	Business Education
Mary Schneck	Charles W. Woodward High	French
Susan Silverman	Newport Junior High	Special Education
Laura Stoskin	North Chevy Chase	Elementary
Elissa Weinroth	Potomac Elementary	Elementary
William Welsh	Einstein High	Mathematics

COURSE EVALUATION FORM

Title of Course: IT-02 Computer-Assisted Instruction Training Program

The following list constitutes the major performance objectives of this course.

Evaluate the attainment of the following objectives in relationship to your ability to design and develop another modular instructional package without staff guidance and supervision.

Performance Objectives	Part I				Part II				
	Participant Mastery				Course Instruction (Check one)		Course Time (Check one)		
	Before Course (Check one)		After Course (Check one)						
	Yes	No	Yes	No	Effective	Ineffective	Too Short	Adequate	Too Long
The participant (supporting teacher):									
1. Given a diagram illustrating educational technology, flow chart form, describes the function and purpose of each step.									
2. Constructs a terminal objective for a learning experience which describes a. what the learner will do at completion of the experience, b. the conditions under which performance will occur, and c. the criteria defined as success.									
3. Performs a task analysis on a terminal objective and writes the enabling objectives.									
4. Arranges enbling objectives into a logical sequence and draws this sequence as a hierarchy.									
5. Constructs a pretest and posttest for the terminal objective.									
6. Constructs at least one criterion test item for each enabling objective.									
7. Develops and flowcharts an instructional strategy for the learning experience.									
8. Constructs a sequence for the learning experience in which the principles of programmed instruction and individualization are employed.									

Time-Sharing Project

What has become known as the Time-Sharing Project developed when the Board of Education awarded a $20,000 item in the FY73 budget to lease terminal and computer services for selected secondary schools in Montgomery County. The contract was awarded to DIALCOM, Incorporated, a commercial company located at 1104 Spring Street, Silver Spring, Maryland. The hardware configuration utilized by this company consists of a Honeywell 1648 Time-Sharing System. In each involved school, two remote terminals (Model 33 ASR's) were installed: one with on-line, and one with off-line capabilities.

Eight schools were selected by the Department of Curriculum and Instruction to participate in the project. The objectives for the Time-Sharing Project were:

1. *To support a pilot "Secondary School Mathematics Curriculum Improvement Study"* (SSMCIS) program at two senior high schools. Designed at Columbia University, the SSMCIS curriculum is a unified, contemporary approach to mathematics and relies heavily upon the availability of on-line time-sharing services for learning the BASIC language and using it for problem solving related to particular course material.

2. *To further develop problem solving skills.* Services were to be made available to mathematics and science teachers at two junior high schools for use in teaching the processes followed in solving mathematical problems.

3. *To develop computer programming, problem solving, and computer literacy programs.* Terminals were to be placed in four additional senior high schools to provide students with an opportunity to learn the BASIC programming language for problem solving in their mathematics/science courses. These experiences were to provide pupils with opportunities to use the principles of logic for the exploration of mathematics beyond normal classroom parameters, and to enhance their problem-solving skills simultaneously.

The two schools designated to pilot the tenth grade SSMCIS program were Winston Churchill High School, Potomac, and Thomas S. Wootton High School, Rockville. The remaining six secondary schools were: Bethesda Chevy-Chase High School, Bethesda; Gaithersburg High School, Gaithersburg; Walter Johnson High School, Bethesda; Colonel E. Brooke Lee Junior High School, Silver Spring; Parkland Junior High School, Rockville; and Walt Whitman High School, Bethesda. Churchill and Wootton High Schools received on-line computer services for a total of eight months. The four remaining high schools received services for five and one-half months, and the two junior high schools received services for four months.

The Computer-Assisted Instruction Program's involvement was primarily related to the third objective. Development of a computer literacy course for secondary students had been initiated, thus the finalization of such an effort materialized. The following objectives were defined by the CAI Program for this secondary computer literacy course:

I. The student demonstrates an understanding of the restrictions and human limitations placed upon a computer system by answering five true or false questions. (4 or 5 correct)

II. The student demonstrates an understanding of the use of computer systems for:

   a) mass data storage,
   b) instantaneous information retrieval, and
   c) massive complex equations computation and analysis

   by answering five questions designed to measure his knowledge of these subjects. The test questions demand a student analysis of job functions in relationship to their performance at the most reasonable cost, with the greatest amount of accuracy, and in the shortest period of time. (Criteria 4 or 5 correct)

III. Given a schematic time-line with six dates and three ten-year intervals located, and a list of nine inventors, or processes, or computer systems (lettered A-I), the student writes the letter of the historic event above the date that best approximates time of development. (Correct or 2 letters confused)

IV. Given a flowchart, the student demonstrates a tracing of the logical flow by writing the output required at the various locations.

V. The student demonstrates a capability for programming (in any language) by writing a branching program to perform the functions requested in a designated problem situation. The program developed may contain no logistical errors, but may contain up to two syntactical errors.

To provide a continuity among schools attempting to offer such a computer literacy course, two inservice workshops were held. The first workshop met three hours daily from June 26 through July 14, 1972. DIALCOM, Inc. staff members conducted the first two weeks' instruction which consisted of the following outline:

I. Computers and their use

II. Flowcharts and algorithms

III. BASIC (Part I, II, III)

IV. System usage

V. Writing and debugging programs

VI. Sample application programs

The third week of this workshop was taught by George M. Beckert, mathematics resource teacher at Parkland Junior High School. Material covered was designed to have the participants develop a sequence of objectives with related assessment tasks to teach the BASIC language to secondary school students. Approximately eleven teachers participated in these activities.

A six months in-service workshop of a similar nature began on September 27, 1972, meeting one night a week for three hours. Thomas E. Robinson, a CAI Program staff member and coordinator for the time-sharing project, conducted this seminar, gearing the content directly to the identified computer literacy objectives. The following outline was designed for use as a staff development training guide. All training was intended to assist secondary teachers with the preparation of similar computer literacy courses in their own classrooms.

*I. Computer functions and capabilities

II. Flowcharts

III. History

IV. Computer fundamentals

V. Instruction in BASIC

VI. Methods of teaching a computer language

VII. Administration of time-sharing terminals

VIII. Problem solving applications for use in secondary schools

Twenty-eight teachers participated in these activities.

To evaluate the impact that the computer literacy programs would have on the students in the eight involved schools, pretests and posttests designed to measure attainment of the five objectives were provided to each school. The mathematics departments arranged to pretest the classes that were to receive instruction. They anticipated being able to teach approximately 3,300 students. The number of students who actually received instruction was 1,139. These latter students were posttested and the results follow.

Posttest N = 1,139

	Met Criteria	Did Not Meet Criteria
Objective I	1070	69
Objective II	654	485
Objective III	112	1027
Objective IV	856	283
Objective V	220	1049

Discussion of Results

Although in-service training was provided to representatives of the involved schools, no unified computer literacy course was made available. Each school independently developed a course of studies to meet its individual needs. In many cases, objectives identified for such in-house courses did not coincide with those presented and tested herein.

*A complete referenced outline with subtopics is available upon request.

Recommendations

Agreement will need to be reached on the objectives and criterion test items for the course. William J. Clark, Coordinator of Mathematics and Science, has requested that three teachers, Diane Ippolito, Mary McLaughlin and John Randall, each of whom was involved in the project during 1972-1973, aid in the preparation of these materials. The guidelines for implementation of this program will be available for resource teachers in the nine secondary schools prior to September, 1973.

MODULAR INSTRUCTIONAL PACKAGES

MIP Title	Use	CAI Technique(s)
Operational Programs:		
Fractions (FRACT) Addition and Subtraction	Elementary, Secondary and Adult	Diagnostic Concept Tests, Drill and Practice
Learning About Percents (LAP) Part I – Common Fractions Part II – Decimal Fractions	Elementary, Secondary and Adult	Entering Behaviors Test, Tutorial, Posttest
Operation Whole Numbers (OWN) Addition, Subtraction, Multiplication and Division	Elementary, Secondary, Adult, and Special Education	Diagnostic and Review Testing, Drill and Practice, Tutorial, Posttest
Computer-Managed Geometry (GEOM)	Geometry	Diagnostic Testing Placement, Prescription, Assessment
Dimensional Analysis (DIMEN)	Secondary Mathematics and Science Courses	Diagnostic Testing, Tutorial, Drill and Practice, Posttest
Factoring (FACTR)	Algebra I, Algebra II, Trigonometry and Advanced Algebra	Tutorial, Drill and Practice, Student Control, Posttest
Introduction to Vectors (VECTR)	Trigonometry and Advanced Algebra	Tutorial, Posttest
Problem Solving (PROBE)	Math 10, Algebra I	Tutorial, Student Control
Radical Review (RADIC)	Algebra I, Algebra II	Drill and Practice, Student Control

MIP Title	Use	CAI Technique(s)
Demonstration Programs:		
Introduction to Computer Terminal Components – Audio and Light Pen (TBS)	Kindergarten, 1st Grade	Orientation to terminal, audio and light pen use
Orientation to Junior High School (NEW)	Students Entering 7th Grade	Diagnostic Reading Test, Game
MCPS CAI Demonstration (DEMO)	General Audience	
Programs Developed Elsewhere-In Use:		
Scientific Notation, Logarithms (PRESK) (University of Texas)	Algebra II, Advanced Algebra and Trigonometry	Pretest, Tutorial, Drill, Posttest
Signed Numbers, Factoring, Problem Solving (ALGEB) (Philadelphia-Pittsburgh Consortium)	Algebra I, Algebra II	Entering Behaviors Test, Tutorial, Drill, Posttest
Punctuation (PUNCT) (McGraw-Hill, University of Texas)	English 10, English 11, English 12	Pretest, Tutorial, Drill, Posttest
Teacher-Training Programs: (Developed at Pennsylvania State University)		
Early Identification of Handicapped Children (CARE1)	Elementary and Secondary Personnel	Pretest, Tutorial, Posttest
Education of Visually Handicapped Children (CARE4)	Elementary and Secondary Personnel	Tutorial, Simulation, Posttest

MIP Title	Use	CAI Technique(s)
Ratio and Proportion (RATIO)	Algebra II, Trigonometry and Advanced Algebra, Geometry	Tutorial, Student Control
Slope of the Line (SLOPE)	Algebra I, Algebra II, Trigonometry and Advanced Algebra, Geometry	Entering Behaviors Test, Tutorial
Trigonometric Solutions of Right Traingles (TRG)	Math 9, Math 10	Tutorial
Car Ownership (APL)	Math 10, Vocational Mathematics	Simulation
Volume-Area Investigation (APL)	Math 9, Math 10, Vocational Mathematics	Inquiry, Student Control
Perimeter-Area Investigation (APL)	Math 8, Math 9, Math 10	Inquiry, Student Control
Limit Dimensioning (DRAFT)	Industrial Arts	Pretest, Entering Behaviors Test, Diagnostic Test, Tutorial, Posttest
Limit Dimensioning of Mating Machine Parts (DRAFT)	Industrial Arts	Tutorial, Posttest
Fully Automatic Real-Time Time Computer Election (FARCE) (APL)	Problems of the 20th Century, U. S. History and Government	Simulation
Latitude and Longitude (GEOG)	Social Studies, Geography 7 and Geography 8	Tutorial, Posttest
Passé Composé (FRENC)	French II, French III	Prestest, Entering Behaviors Test, Tutorial, Drill,
Developmental Programs:		
Reading, Arithmetic, Phonics, Language Arts (RAP)	First Grade	Assessment

ERIC

MIP Title	For	CAI Technique(s)
Programs Not In Use:		
Measuring with the Vernier Caliper (VERNR)	General Science	Tutorial
Acid-Base Titration (APL)	Chemistry	Simulation and Drill
Alkanes I and II (ALKAN)	Chemistry	Tutorial
Balancing Chemical Equations (APL)	Chemistry	Drill and Practice
The Gas Laws (APL)	Chemistry	
Charles' Law		Simulation
Charles' Law		Drill
Boyle's Law		Simulation
Boyle's Law		Drill
Pressure-Temperature		Simulation
Pressure-Temperature		Drill
Use of Oxidation Potential Table (CHEM-0)	Chemistry	Drill
Writing Chemical Formulas (CHEM-10)	Chemistry	Diagnostic, Testing, Tutorial, Drill
Analysis of Laboratory Data (APL)	Physics	Problem Solving
Area Under a Curve (APL)	Physics	Tutorial, Drill and Practice, Problem Solving
Construction of a Lens (PHYS-0)	Physics	Tutorial
Force Between Charged Particles (APL)	Physics	Simulation
Motion in Earth's Gravitational Field (APL)	Physics	Simulation and Drill
One-Dimensional Elastic Collision (APL)	Physics	Simulation