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ABSTRACT

Cooperation between the Appalachia Educational Laboratory, International Business Machines, and the Computer Assisted Instruction Laboratory of the Pennsylvania State University led to an attempt to provide inservice education in modern mathematics for elementary school teachers throughout Appalachia and other areas which are geographically difficult to reach. Mobile vans were used, with computer assisted instruction mounted in them. The first eight weeks of implementation of this project are reported here, including a description of the program, evaluations of achievement and attitudes towards mathematics and computer-assisted instruction, curriculum revisions, and computer system operation and utilization. (EM 011 037 through EM 011 043, EM 011 046, EM 011 047, EM 011 049 through EM 011 058 are related documents.) (RH)

C·A·I

COMPUTER ASSISTED INSTRUCTION LABORATORY

COLLEGE OF EDUCATION · CHAMBERS BUILDING

THE PENNSYLVANIA STATE UNIVERSITY · UNIVERSITY PARK, PA.

INSERVICE MATHEMATICS EDUCATION FOR ELEMENTARY SCHOOL TEACHERS VIA COMPUTER-ASSISTED INSTRUCTION

INTERIM REPORT

June 1, 1969

No. R-19

Note to accompany the Penn State Documents.

In order to have the entire collection of reports generated by the Computer Assisted Instruction Lab. at Penn State University included in the ERIC archives, the ERIC Clearinghouse on Educational Media and Technology was asked by Penn State to input the material. We are therefore including some documents which may be several years old. Also, so that our bibliographic information will conform with Penn State's, we have occasionally changed the title somewhat, or added information that may not be on the title page. Two of the documents in the CARE (Computer Assisted Remedial Education) collection were transferred to ERIC/EC to abstract. They are Report Number R-36 and Report Number R-50.

Jocelyn Carroll, ERIC/EM

The Pennsylvania State University

Computer Assisted Instruction Laboratory
University Park, Pennsylvania

INSERVICE MATHEMATICS EDUCATION FOR ELEMENTARY SCHOOL TEACHERS VIA COMPUTER-ASSISTED INSTRUCTION

Dryden, Virginia

Sponsored by

The Appalachia Educational Laboratory, Inc.
Charleston, West Virginia

Principal Investigator

Keith A. Hall

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Harold E. Mitzel
C. Alan Riedesel
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Cecil Trueblood

Interim Report
June 1, 1969

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PREFACE

The conception of an idea to place a computer-instructional system in a mobile facility in order to provide inservice education for school personnel throughout Appalachia and other areas which are geographically difficult to reach can be traced to a letter written by Harold E. Mitzel, Assistant Dean for Research in the College of Education at The Pennsylvania State University, to Dr. Benjamin Carmichael, Director of the Appalachia Educational Laboratory, Inc. at Charleston, West Virginia, in May 1967. Much time and effort was devoted to nurturing this idea by the staff of the Appalachia Educational Laboratory, the Computer Assisted Instruction Laboratory at Penn State, and the International Business Machines Corporation. The Appalachia Educational Laboratory concentrated their effort on developing interest among the public school people in Appalachia and developing the financial support for such a project. The staff of the CAI Laboratory at The Pennsylvania State University concentrated much effort into revising and polishing a course in modern mathematics for elementary school teachers and the addition of components to the course to provide specific instruction in methods of teaching. Staff members from the IBM Corporation focused their attentions on the engineering and support problems for such as operation. Careful plans and details were developed for mounting a computer instructional system in two mobile vans so that it could be moved from location to location in the Appalachia region. Other problems to be considered were those of providing support personnel throughout the region to maintain the facilities once they were installed.

After the three participating agencies had attended to the details of the task within their area of responsibility--AEL had found support from local educational cooperatives to finance such an installation, Penn State had revised and developed the modmath curriculum to include the methods components, and IBM had planned and designed mobile facilities to house such an installation, a site evaluation team recommended to the Division of Educational Laboratories that the project not be supported on the basis that it was a high risk project and that the feasibility of using such a computer configuration with sixteen student had not yet been demonstrated. It was further pointed out in the site evaluation report that IBM would not be able to provide the engineering maintenance for such a system in the field. In spite of these objections and alleged shortcomings, AEL, Penn State University, and IBM were determined to demonstrate that the project was feasible and could be successfully executed. Therefore, about March 1, 1969, an IBM 1500 system was delivered to the United Data processing facility in Dryden, Virginia, and installed ready for operation about ten days later. The IBM Corporation installed the computer system and provided the engineering support to demonstrate that indeed the system was capable of supporting the 16 terminals and that their Corporation was capable of providing the engineering support necessary. The Appalachia Educational Laboratory provided the administrative effort necessary to orient the local school administrators and teachers to the program and to encourage the teachers to enroll and take the program. This report documents the project at its first setting in Dryden, Virginia. At this time the project is continuing at a second setting in the Gladeville Elementary School at Galax, Virginia, for another eight-week period and will then be moved to California, Pennsylvania, for a third setting during the summer months.

At this point there is no doubt in the minds of those who have been involved in the project that the concept of a mobile CAI facility is a feasible and effective means of providing inservice education to teachers who would not otherwise have such an opportunity.

Keith A. Hall
June 1, 1969

ACKNOWLEDGEMENTS

Special recognition must go to a number of people who have been actively working and lending their support to this inservice education project: Mr. Charles Cox, Federal Projects Coordinator, and Mr. Benjamin Coxton, Coordinator of Project DILENOWISCO, who coordinated the activities at the setting in Dryden, Virginia, by arranging for physical facilities as well as coordinating with the other school administrators to encourage teachers to participate in the course. Special recognition must also go to the IBM Corporation for making the demonstration possible and to Mr. Glenn Moore, the IBM Customer Engineer at Dryden who provided the maintenance and engineering support for the system.

Acknowledgements must also go to the men who served as systems managers during the illness of our regular manager and to the families of these men who accepted the inconvenience caused by the situation: Mr. Frederick Chase, Mr. Richard Thompson, and Mr. Harry Maurer.

Special recognition must also go to Mrs. Betta Kriner, Mrs. Diane Knull, Mrs. Kris Sefchick, Mrs. Barbara Lippincott, and Mrs. Carol Rockey for their efforts in developing materials, reproducing student materials, and budget management on the project.

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COMPUTER-ASSISTED INSTRUCTION AT DRYDEN, VIRGINIA

Spring, 1969

Need

The importance of early mathematics education to students' intellectual growth is becoming increasingly evident. It is clear that elementary school teachers have an obligation to keep up-to-date and better informed in mathematics--not only about happenings which have implications for their teaching content, but also how the process of mathematics instruction might be improved.

However, an objective look reveals that the mathematics teaching skills of Appalachian elementary school teachers are, in too many instances, inadequate. There are two important reasons for this condition. The first reason is lack of effective preservice preparation. The Committee on Undergraduate Programs in Mathematics (CUPM) has recommended four mathematics courses for the preservice training of elementary school teachers. Relatively few colleges and universities have been able to make such arrangements. In fact, many new teachers entering the field have the same level of expertise in mathematics as those who presently are there.

The second reason is lack of adequate inservice education. Although many programs are offered at the state and local levels, these programs have been generally sporadic, of short duration, poorly staffed, and frequently designed solely to cope with some emergency (such as an adoption of a new textbook series).

Furthermore, attempts to improve the quality of this inservice education within the current educational framework have been frustrated by the difficulties in attracting master teachers, obtaining college credit, and arranging for release time.

Relatively few Appalachian elementary school teachers have attended a federally-sponsored institute of any kind, mainly because these institutes generally require an extended stay away from home. In Pennsylvania, for example, it is estimated that there are in excess of 58,000 elementary school teachers (based on an elementary school population of 1,716,252), and only 188 of these have attended a federally sponsored institute (Bureau of Statistics, 1967, 1968).

<u>Because of inadequate preservice and inservice mathematics training programs, there is widespread agreement that a critical need exists for new methods of providing quality inservice mathematics instruction.</u>

In spite of the unsatisfactory conditions of current inservice programs, studies indicate that quality improvements in inservice training can and should be accomplished. Huettig and Newell (1964), for example, found that teachers with courses in modern mathematical content have a significantly better attitude toward curricular change in mathematics. Rudd (1954) found inservice courses to be of a higher caliber when individual background was taken into consideration, and the inservice course was accomplished at the local level in close proximity to the elementary classroom.

Another important finding was reported by Houston, Boyd, and DeVault (1962), who worked with 252 elementary teachers in a multi-media approach using closed circuit television, lecture, question-discussion, and written materials. They indicated that teachers preferred the written materials and the question-discussion approach of teaching. The researchers stated, "The findings of this study would (sic) indicate that administrators should consider procedures for individualizing inservice education programs for teachers." Dutton (1966) also noted that use of programed instructional materials seem to provide numerous opportunties to diagnose students' subordinate knowledge and skills essential for sound sequential learning and expansion of mathematical concepts. In another study, Dutton and Hamlin (1966) stated that the identification of weaknesses teachers have in understanding the new mathematics and teaching to overcome those weaknesses should be an important part of an inservice program.

The research suggests that proposed teacher improvement programs should be based on the question-discussion method, individualized programs, and programed instructional materials. Computer-assisted instruction is the one technological innovation which can utilize all of these components in one comprehensive program.

<u>Based on these studies and considerations of alternative programs, it is concluded, therefore, that a computer-based program in modern mathematics is the best choice for accelerating the accessibility of quality inservice education for mathematics teachers in Appalachia.</u>

The primary target of the program was the teacher of elementary pupils in a sparsely settled area of Appalachia. The stereotype of this teacher is that of a woman who would have to double as a housewife and student long enough to attend college classes to upgrade her knowledge in modern mathematics. This dual responsiblility often prevents the teacher from attending college; she will therefore spend another fifteen years in the classroom with no improvement in the quality of her service unless new techniques of inservice education are provided. Computer-assisted instruction offers the potential for meeting inservice training needs of the students, teachers, and the administration.

Objectives

The goal of the project was to field test a program of inservice education in modern mathematics and mathematics teaching methods for elementary teachers in the Appalachian region. An IBM 1500 instructional system was installed in Dryden, Virginia, to administer the computer-based course to the teachers. This system was used during later afternoon and evening hours to provide individualized instruction for elementary school teachers who drove in from a radius of approximately 20 miles. Records of the learning histories of the participating teachers were compiled and analyzed for evaluating the effectiveness of the course and for making course revisions.

Computer Configuration

The IBM 1500 student station consists of four optional display/response devices which may be used individually or in combination. The central instrument connected to the computer consists of a cathode-ray tube screen with sixteen horizontal rows and forty vertical columns for a total of 640 display positions. Information sufficient to fill the screen is available in micro seconds from an internal random access disk. A light-pen device enables the learner to respond to displayed letters, figures and graphics by touching the appropriate place on the screen. A part of the CRT device is a typewriter-like keyboard which makes it possible for the learner to construct responses, have them displayed at any author-desired point on the CRT screen and receive rapid feedback in the form of an evaluative message. Four dictionaries of 128 characters each of the course author's own design are capable of being used simultaneously; thus, it would be technically feasible to teach the symbols of Sanskrit, Chinese, English, and Greek simultaneously by means of CAI. An image-projector loaded with a 16mm microfilm is capable of holding 1000 images on a single roll and of accessing forty images per second under program control. An audio play/record device has just recently become available but was not utilized for this project. An electric typewriter on the system is a separate device which enables the student to receive a hard copy of the interaction or dialogue between himself and the computer.

The computer central processor which can accommodate up to a total of thirty-two student stations (each complete with four devices) is an IBM 1130 computer with 32,768 words of core storage. (Sixteen stations were sufficient to allow 150 - 200 students to complete the instructional materials used for this project in about 8 weeks.) In addition to the usual peripheral equipment, the central processor depends upon five IBM 2311 disk drives (2,560,000 words) for the storage of usable course information and operating instructions. Twin magnetic tape drives record the interaction between the program and the student for later analysis and course revision. Core storage cycle time is 3.6 micro seconds and read/write time for disk storage is 27.8 microseconds per word.

Instructional Program

The computer-assisted instruction course in mathematics for elementary teachers and methods of teaching mathematics for elementary teachers was developed by Professors C. Alan Riedesel, Marilyn Suydam, and Cecil Trueblood of The Pennsylvania State University. The course adheres rather closely to the CUPM Level 1 recommendation with about 80 per cent of the course devoted to mathematical content and 20 per cent devoted to the methods of teaching mathematics. The methods units were interspersed throughout the program so that each would be studied immediately following the presentation of the related content.

The course utilizes an integrated approach relying not only on tutorial activity at the computer terminal but on the integration of printed instructional materials and manipulative devices to be used at the terminal and in the teacher's classroom. Each participant in the project received a copy of Guiding Discovery in Elementary School Mathematics by C   iesel and published by Appleton-Century Crofts, a handbook containing suggested lesson plans and problem assignments, and an assortment of manipulative devices such as Cuisenaire rods and counting sticks to use in their classroom. A course description is included in the appendices of this report. A pre- and post-test of mathematics content, a pre- and post-test of the participant's attitude toward mathematics and a post-test of attitude toward CAI were administered to all participants in the project. The data from these inventories are documented elsewhere in this report.

Participants

About 164 students registered for the inservice mathematics CAI course. Of these, 120 registered for university credit at the University of Virginia (60 for graduate credit and 60 for undergraduate credit). Ninety of the 164 students were elementary teachers. One hundred and twenty-nine students completed the CAI course. Only one student was unable to complete the course during the time (8 weeks) that the computer system was located at Dryden, Virginia, with the remainder of the students dropping out for various personal reasons.

Course Completion Time

According to the computer clock records, the average completion time was 21 hours. This average does not include pre-test time, post-test time, or time used to take the "SOS" CAI opinion test at the student station. It also does not include time that students may have spend seated at a terminal but not signed on to the course itself. Minimum clock time for the fastest students (mostly high school math teachers) was 12 hours with the maximum completion time being about 56 hours.

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APPENDIX

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Course Description: elmath

The CAI course elmath is designed to present mathematical content and methods of teaching that content in the elementary school. The content component was developed at The Pennsylvania State University by Dr. C. Alan Riedesel and Dr. Marilyn N. Suydam. The methods component was developed by Dr. Cecil R. Trueblood with Dr. Riedesel and Dr. Suydam.

The primary purpose of the content materials is to present the mathematics which a teacher should know in order to develop a successful program in the elementary school. It is based on CUPM recommendations for Level 1 courses, modified to meet the actual requirements of the schools in which it is visualized for use. The methods materials place stress on various strategies and techniques, including the use of manipulative materials.

As over-all learning outcomes, the teacher should be able to understand and apply:

(1) the mathematical content

(2) generalizations about teaching procedures, including:

- (a) Physical world situations should be used to facilitate concept development.
- (b) Many varying materials should be used to facilitate concept development.
- (c) Experiences should range from the concrete to the abstract.
- (d) Individual differences must be considered in planning and in teaching.
- (e) Pupils should be asked to discover and use many varying ways of finding solutions to problems.
- (f) Pupils should be asked to explain, deduce, generalize, and apply.
- (g) Questions of many types should be asked to provoke discussion, develop concepts, and refocus on problems.

In addition to the CAI program, a textbook on teaching elementary school mathematics is required: Riedesel, C. Alan, Guiding Discovery in Elementary

School Mathematics (New York: Appleton-Century-Crofts, 1967). A handbook with a summary of mathematical content and a section on activities and materials to use in the classroom is also provided: Part I, Help to You in Learning Mathematics, by Roy F. Shortt (Keuka College, Keuka Park, New York), and Part II, Help to You in Teaching Mathematics, by Cecil R. Trueblood (The Pennsylvania State University).

For use in evaluation of learning, there are an eighty-item test ("A Test on Modern Mathematics," Forms G and H, by Marilyn N. Suydam, Cecil R. Trueblood, and C. Alan Riedesel) and an attitude scale ("Attitude Toward Mathematics," by Marilyn N. Suydam and Cecil R. Trueblood). A scale to measure changes in attitude toward CAI is also available.

An outline of the course follows.

Chapter 1: Sets and Early Number Experiences

Content

1. Sets
   a. Elements of sets
   b. Finite and infinite sets
   c. Defined sets
   d. Set notation
   e. Empty set
   f. Universal set
   g. Subsets

2. Set relationships
   a. Equality
   b. Equivalence

3. Set operations
   a. Union
   b. Intersection

4. Complement of a set

Methods

This section focuses attention on why and how sets are presented in early number work. Attention is also directed toward the materials and techniques the teacher should use and the questions she should ask. Levels of pupil performance are considered in terms of types of pupil response.

Chapter 2: Exponents

Content

1. Interpreting exponential notation
   a. Repeated factors
   b. Powers: base and exponent

2. Expressing in exponential form

3. Expanding from exponential form

4. Computation with exponents
   a. Multiplication
   b. Division
   c. Addition and subtraction

5. Zero as an exponent

6. Using expanded notation

Methods

How to teach exponential notation so that pupils see its usefulness is featured. Various pupil-teacher exchanges are presented. Use is made of graph paper and blocks to illustrate exponential forms.

Chapter 3: The Hindu-Arabic System

Content

1. Numerals and word names for numbers

2. Place value
   - a. Numerals and names through thousands place
   - b. Patterns
     - (1) Powers of 10
     - (2) Expanded form and standard numerals
   - c. Chart: periods and place value through quadrillions
     - (1) Reading the numeral
     - (2) Completing the chart

Methods

Introducing pupils to the use of place value charts is considered. This is connected with work with the abacus and multi-base arithmetic blocks. The reading of numerals to quadrillions is also considered.

Chapter 4: Other Numeration Systems

Content

1. Introduction to base eight
   a. Symbols: counting
   b. Place value
   c. Changing from base ten to base eight
      (1) Finding powers of the base
      (2) Division by the base

2. Introduction to base five
   a. Changing from base five to base ten
   b. Changing from base ten to base five

3. Characteristics of any numeration system
   a. Number of symbols
   b. Writing the base

4. Introduction to base twelve
   a. Changing from base twelve to base ten
   b. Changing from base ten to base twelve

5. Introduction to base two
   a. Changing from base ten to base two
   b. Changing from base two to base ten

6. Addition in other bases
   a. Base five
   b. Base two

7. Multiplication in base five

Methods

Ways of introducing other numeration systems are presented. Use of materials such as the place value chart is considered, and attention is directed to points at which pupils may have difficulty.

Chapter 5: Addition of Whole Numbers

Content

1. Addition as a binary operation

2. Addition as one of four operations
   a. Relation to subtraction
   b. Relation to multiplication

3. Addition as the union of disjoint sets

4. Counting as the basis for addition: use in problem solving

5. Aids for teaching addition
   a. Abacus
   b. Number line
   c. Cuisenaire rods
   d. Place value frame

6. Properties and principles of addition
   a. Closure
   b. Commutativity
   c. Associativity
   d. Identity element

7. Addition basic facts: use of the table

8. Addition algorithms for multi-digit examples
   a. Use of place value
   b. Use of properties
   c. Regrouping
   d. Expanded notation forms

9. Historical forms for addition
   a. Sandboard method
   b. Scratch method
   c. Front-end addition

10. Checking addition
    a. Excess of nines
    b. Excess of elevens

Methods

For this chapter, the methods component is interwoven with the content. Stress is placed on the use of verbal problems and manipulative materials such as the abacus and Cuisenaire rods.

Chapter 6: Subtraction of Whole Numbers

Content

1. Subtraction on the number line

2. Subtraction as the inverse of addition

3. Terminology
   a. Addend, missing addend, sum
   b. Minuend, subtrahend, difference

4. Subtraction in terms of sets
   a. Complements
   b. Difference between universal set and subset

5. Properties and principles of subtraction
   a. Closure
   b. Commutativity
   c. Associativity
   d. Compensation and renaming

6. Subtraction basic facts: use of the addition table

7. Subtraction algorithms
   a. For basic facts
      (1) Additive method
      (2) Take-away method
   b. For multi-digit examples
      (1) Decomposition
         (a) Additive
         (b) Take-away
      (2) Equal additions
         (a) Additive
         (b) Take-away

8. Checking subtraction
   a. Adding
   b. Excess of nines
   c. Excess of elevens
   d. Complementary method
   e. Scratch method

9. Subtraction in base eight

Methods

Procedures for introducing subtraction to pupils are developed. Also reintroduction using the abacus as a vehicle is presented, and attention is focused on ways of teaching multi-digit subtraction using expanded notation.

Chapter 7: Multiplication of Whole Numbers

Content

1. Multiplication as repeated addition, using the number line
2. Terminology
   a. Multiplier, multiplicand, product
   b. Factors and product
3. Multiplication in terms of sets
4. Arrays and ordered pairs
5. Properties and principles of multiplication
   a. Identity element
   b. Closure
   c. Commutativity
   d. Associativity
   e. Distributivity
6. Multiplication basic facts: use of the table
7. Multiplication algorithms for multi-digit examples
   a. Regrouping
   b. Use of place value
8. Checking multiplication
   a. Use of properties
   b. Excess of nines
   c. Excess of elevens
9. Historical forms for multiplication
   a. Finger reckoning
   b. Lightning method
   c. Scratch method
   d. Lattice method
   e. Duplation methods
10. Modulus multiplication
    a. Mod 2
    b. Mod 7

Methods

Use of arrays in teaching multiplication is developed. Emphasis is placed on providing pupils with varying methods for finding answers to multiplication questions.

Chapter 8: Division of Whole Numbers

Content

1. Relation of division
   a. To multiplication
   b. To subtraction

2. Terminology
   a. Dividend, divisor, quotient
   b. Types: partition and measurement

3. Properties and principles of division
   a. Closure
      (1) Exact division
      (2) Inexact division
   b. Commutativity
   c. Associativity
   d. Right distributivity
   e. Use of zero except as a divisor
   f. Identity element

4. Division algorithms
   a. For basic facts: use of the multiplication table
   b. For multi-digit examples
      (1) Subtracting groups of the divisor
      (2) Use of place value
      (3) Estimation of quotient
         (a) Approximation
         (b) Compensation
         (c) Determining devisibility

5. Historical forms for division
   a. Galley method
   b. A danda method
   c. Division by factors
   d. Excess of nines

6. Division in base four

Methods

Procedures for the diagnosis of pupil difficulties in division are developed. Provision for individual differences is focused on through the study of procedures for estimating the quotient in division.

Chapter 9: Functions

(to be developed)

Chapter 10: Integers

Content

1. Defining the set of integers
   a. Negative signed numbers
   b. Additive inverse

2. Computation with integers

3. Properties and principles of integers
   a. Closure
   b. Commutativity
   c. Associativity
   d. Distributivity
   e. Identity element

4. Order relations of integers

Methods

Three strategied for introducing a lesson are analyzed and compared. The way in which a teacher can use a textbook with other materials is developed.

Chapter 11: Fractions

Content

1. Defining the set of rational numbers

2. Terminology of fractions

3. Uses of fractions
   a. To express parts of a group and parts of a whole
   b. To name a rational number
   c. To indicate division
   d. To express a ratio

4. Characteristics of fractions
   a. Identity element
   b. Equivalence
   c. Cross-products test
   d. Renaming in simplest form
      (1) Prime numbers
      (2) Composite numbers
      (3) Numbers that are relatively prime

5. Order relations of fractions; mixed forms

6. Properties of fractions
   a. Commutativity
   b. Associativity
   c. Distributivity

7. Computation with fractions
   a. Addition
      (1) Like denominators
      (2) Unlike denominators
   b. Finding the L.C.M.
   c. Finding the G.C.D.
   d. Subtraction
      (1) Like denominators
      (2) Unlike denominators
   e. Multiplication
   f. Division
      (1) Common denominator method
      (2) Multiplicative inverse method (inverse)

Methods

Attention if focused on a lesson plan for summarizing the various uses of fractions. The selection of behavioral objectives and analysis of strengths and weaknesses of the plan are included.

Chapter 12: Decimals

Content

1. Place value for decimals

2. Reading and writing decimals

3. Locating decimals on the number line

4. Renaming
   a. Fractions as decimals
   b. Decimals as fractions

5. Terminating decimals

6. Non-terminating decimals
   a. Repeating
   b. Non-repeating

7. Computation with decimals

Methods

Use of a physical world situation to introduce decimals is emphasized with the presentation of a lesson with an odometer. Pupil participation through the use of multiple solutions is reviewed, and non-verbal problems are suggested.

Chapter 13: Ratio and Per Cent

Content

1. Ratio
   a. Expressing ratios
   b. Solving problems with ratios
   c. Using the cross-product method

2. Per cent
   a. Three types of problems
      (1) What is N% of a number?
      (2) What per cent is one number of another number?
      (3) Find the total (100%) when a per cent is known
   b. Five approaches to solving each type of problem
      (1) Decimal
      (2) Ratio
      (3) Unitary-analysis
      (4) Formula
      (5) Equation

Methods

This section is essentially a review and test of material presented in chapter 10 of the course textbook by Riedesel. When and how ratio and per cent should be developed are emphasized.

EVALUATION OF ACHIEVEMENT

Harold E. Mitzel and Marilyn N. Suydam

Development of the Mathematics Achievement Test

The "Test on Modern Mathematics," Forms G and H (by Marilyn N. Suydam, Cecil R. Trueblood, and C. Alan Riedesel) was developed to serve as a pre- and post-test measure of achievement for the computer-assisted mathematics course for elementary teachers (EJmath). The multiple-choice test is designed to provide a representative sampling of mathematical content from each of the twelve chapters in the course in order to test understanding of the concepts contained in the CAI mathematics program. Although about twenty per cent of the student's "on-line" time dealt with the teaching of mathematics in the elementary school, questions on this material were not included in the achievement examination.

From a pool of approximately 300 multiple-choice questions composed of items used to test a previous version of the course (Long and Riedesel, 1967), the basic examination was constructed. The pool was constructed by writing test questions which fit the numbers of knowledge, understanding and application objectives included in each chapter. Texts in mathematics education which were used to construct the course were consulted in the preparation of the test questions. In addition, the authors of the test were assisted by a mathematician who evaluated each item for appropriateness to the course material and for mathematical accuracy. This test in our opinion represents a first approximation to a criterion-referenced examination on which a population of elementary teachers should be expected to achieve a mastery level of about ninety per cent after instruction.

Form G of the "Test on Modern Mathematics" was used as the pre-test, while Form H served as the post-test. The two forms contain the same items, except that: (1) the numerical values are changed in about one-half of the items, and (2) the order of answer options is different on almost all items. Because there were no substantive changes in content or format, we make the assumption that Forms G and H are equivalent. Time and the appropriate number of experimental subjects from the population of elementary school teachers were not available to collect the data needed to establish psychometric equivalence.

Table 1 shows the pre- and post-treatment results of the administration of the "off-line" mathematics achievement test. A total of 119 persons provided usable and identifiable answer sheets for the two test administrations which were taken approximately eight weeks apart. In the intervening period, the teachers spent an average of twenty-one hours on the course material.

In studying the results of Table 1, we make the assumption that the eighty items of the test represent an absolute criterion of achievement in this course and that theoretical mastery of the course objectives is attained when a student answers all eighty items correctly. In most practical achievement testing situations, a ninety per cent criterion is ordinarily considered realistic. In the case of Forms G and H, we find considerable discrepancy from that goal which we attribute to two causes. First, the items being a first cut do contain some "transfer of knowledge" objectives which were not specifically taught in the CAI program. Second, there are probably not enough direct practice materials and short quizzes within the program to enable the less able students to reach the desired objectives. The first difficulty can be overcome by a careful reexamination of the hierarchy of tasks involved in the solution of the problems. The second difficulty can be ameliorated by additions and deletions to the program of instruction. As shown in Table 1, approximately twelve per cent of the Dryden students had, by virtue of their performance on the pre-test, already achieved seventy per cent of the objectives of the course. For this group, there was relatively little room to grow and, in the pragmatics of an inservice teacher education offering, it is impossible to withdraw the opportunity for self-improvement once the pre-test results are available.

We have omitted the usually reported measures of test reliability based on the discriminating power of the accumulated test questions. These considerations are inappropriate for situations where mastery of subject matter is desired instead of each learner's relative position on an achievement scale.

In spite of the imperfections in the achievement test (and/or the instruction program), the data show that the students at Dryden were able to increase their mean achievement from approximately fifty per cent of the material to seventy-four per cent after an eight-week period of

Table 1

Frequency Distributions of Pre and Post Mathematics Achievement for Educators Taught by CAI at Dryden, Virginia, Spring 1969

Per cent of Criterion Test Correct	Frequency Pre-test, Form C N = 119	Cum. Fre. in Per cent	Frequency Post-test, Form H N = 119	Cum. Fre. in Per cent
95 - 99	1	100.00	10	100.00
90 - 94	3	99.16	10	91.60
85 - 89	6	96.64	13	83.19
80 - 84	2	91.60	16	72.27
75 - 79	0	89.92	16	58.82
70 - 74	7	89.92	14	45.38
65 - 69	3	84.03	12	33.61
60 - 64	9	81.51	7	23.53
55 - 59	14	73.95	5	17.65
50 - 54	9	62.18	7	13.45
45 - 49	9	54.62	2	7.56
40 - 44	13	47.06	2	5.88
35 - 39	17	36.13	3	4.20
30 - 34	15	21.85	0	1.68
25 - 29	7	9.24	2	1.68
20 - 24	3	3.36		
15 - 19	0	0.84		
10 - 14	1	0.84		
Mean	49.86		73.97	
Median	46.40		76.20	
Mode	37.00		79.50	

N.B. Descriptive statistics were calculated from grouped data.

CAI mathematics instruction.[1] Roughly, a one-quarter increase in mathematics knowledge can be attributed to the impact of the course within the

[1] The raw score difference between pre- and post-test means was 19.36 which, when evaluated by t-test for correlated means, gave the following results: $t = 19.09$ $p < .001$ d.f. = 118.

interpretative limitations of the test's characteristics. No other experiences with the content of mathematics were reported by the students during the eight-week period. Indeed, by teaching a full schedule in the Virginia public schools and commuting to Dryden two or three days per week, little time could have remained to the teachers for independent study of mathematics.

REFERENCES

Long, Samuel M. and Riedesel, C. Alan, _Use of Computer Assisted Instruction for Mathematics In-service Education of Elementary School Teachers._ Final Report, Grant No. OEG-1-7-661970-0383, Project No. 66-1970, University Park, Pa., October 31, 1967.

EVALUATION OF ATTITUDES TOWARD MATHEMATICS

Harold E. Mitzel, Marilyn N. Suydam and Richard L. Kohr

When a new instructional technique becomes available, educators frequently are interested in the attitudinal effects of the methodology on the subject matter being taught. Computer-assisted instruction is of particular interest in this connection because of humanistic fears that machines will somehow replace fundamental human activities. In the case of attitudes toward mathematics and things mathematical, we are, to be sure, more concerned with pupils than with teachers. However, if computer usage can awaken dormant interests of elementary teachers in mathematics, then they may be able to transmit an enthusiasm and positive attitude to their pupils. For this reason, we were interested in studying attitude change on the part of Virginia elementary teachers who spent an eight-week period on a computer-assisted instruction course in modern mathematics.

Development of the Mathematics Attitude Scale

The "Attitude Toward Mathematics" scale (by Marilyn N. Suydam and Cecil R. Trueblood) was developed from a pool of seventy-five items selected to express various feelings toward mathematics. The Likert format was used with each statement worded in such a way that its content is favorable or unfavorable. Students then respond in terms of the degree to which they agree or disagree with the statement. Neutral items are not included. To reduce the potential effect of response set, care was taken to include an equal number of positively worded (favorable to mathematics) and negatively worded (unfavorable to mathematics) items.

The seventy-five item pool was submitted to twenty-five examinees who were asked to respond to each item with a five-point scale ranging from "strongly agree" to "strongly disagree." Scale scores were then derived for each item, and the final selection of twenty-six items was based on: (1) the level of the scale scores and (2) independence of content of the item.

The value of the variate on the attitude scale was obtained by assigning arbitrary numerical weights to the options according to the following scheme:[1]

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Positively Worded Items	1	2	3	4	5
Negatively Worded Items	5	4	3	2	1

The theoretical extremes of a distribution of scores with twenty-six items are twenty-six and one hundred and thirty.

On administrations of the "Attitude Toward Mathematics" scale to several hundred students, the reliability (i.e., a measure of internal consistency, Cronbach's Coefficient Alpha) has ranged from .9207 to .9793, with an average reliability of .9554.

Results

The "Attitude Toward Mathematics" scale was administered on a pre-test, post-test basis to the adults enrolled in the computer-presented Elmath course at Dryden, Virginia. The scale was given at the time of registration or at the first instruction session. After the eight-week instruction period, the students were given the scale items and an answer sheet with instructions to mail in their reactions at their earliest convenience.

Pre-post test replies for one hundred and two students were identified for this analysis. The results are shown in Table 1. The mean score on the pre-test was 91.10 and the mean score for the same group of students after completion of the CAI course in modern mathematics was 98.11, a mean increase of 7.01.[2]

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[1] Items are scored on a one-to-five basis rather than zero-to-four in order to facilitate computer processing of the data. Specifically, when zero scores can legitimately occur, the computer cannot distinguish zeros from omits unless a special character compare is performed. This operation must be carried out for each item score which substantially increases processing time. Consequently, the computer program was written to handle positive, non-zero numbers.

[2] The difference between pre- and post-instruction means was evaluated by t-test for correlated measures with the following results:
$t = 6.97$, $p < .01$, d.f. $= 101$.

Table 1

Distribution of Pre- and Post-test Attitude Scale Scores
for 102 Students in CAI Program
Dryden, Virginia, Spring 1969

Score	Pre-test	Post-test
130 -	2	2
120 - 129	4	8
110 - 119	10	17
100 - 109	16	22
90 - 99	25	23
80 - 89	22	16
70 - 79	10	7
60 - 69	6	5
50 - 59	6	2
40 - 49	0	0
30 - 39	0	0
20 - 29	1	0
N =	102	102
Mean	91.10	98.11
Median	90.00	98.60
Standard Deviation	18.76	17.06

N.B. Descriptive statistics were calculated from ungrouped data.

The fact that the teachers at Dryden showed small but statistically significant increases in attitude scores after taking the CAI course in modern mathematics is reassuring. App[illegible]ntly, in this instance fears that interaction with computer terminals might generate negative feelings were unfounded. Hopefully, further computer use in teacher education will illuminate the subject of mathematics and the teaching of mathematics in such a way that greater enthusiasm for it will be demonstrated by elementary teachers who will, in turn, communicate that excitement to their young charges.

EXPRESSED STUDENT OPINIONS TOWARD COMPUTER-ASSISTED INSTRUCTION

Karl G. Borman

It is generally acknowledged that student opinion is an important variable to be considered when one is trying to maximize the learning process. A student with a positive opinion toward his teacher and the subject material will be more motivated to learn and retain the material than the student with a negative opinion toward the teacher and subject matter. Conversely, if a teacher, or more generally a method of instruction does not result in a favorable student opinion the probability that the student will have difficulty learning and retaining the information is increased. Therefore, in evaluating, a method of instruction, it would be helpful to have a measure of student opinion toward that method of instruction as well as a measure of the knowledge gained from use of that particular method of instruction. Ideally, the resulting student opinion should be favorable toward the method of instruction, as indicated above.

The Opinion Survey

An instrument for measuring a student's opinion toward computer-assisted instruction is currently under development in the Computer Assisted Instruction Laboratory at The Pennsylvania State University. The instrument is composed of 42 items related to the student's experiences while taking a course via CAI and is administered at a student terminal (on-line administration). The items were adapted from a paper and pencil test (off-line administration) previously developed at Penn State (Brown, 1966). Each item is a statement that could be made about CAI, or one's experiences with CAI. Care was taken to equalize the number of positively worded items with the number of negatively worded items. The student uses the light pen to indicate the degree to which he agrees with the statement (strongly disagree, disagree, uncertain, agree, strongly agree) or the degree of applicability of the statement (all the time, most of the time, some of the time, only occasionally, never). (See Appendix). A weighting between 1 and 5 was was then assigned to each response, a weighting of 1 indicating an extremely unfavorable opinion toward CAI and a weighting of 5 indicating an extremely favorable opinion toward CAI.

This method of item scoring provides certain bench marks for the interpretation of the results. The theoretical score values between 42 (42 x 1 = 42) and 210 (42 x 5 = 210) a score of 42 indicating an extremely negative opinion toward CAI and a score of 210 indicating an extremely positive opinion toward CAI. A score of 126 (42 x 3 = 126) indicates a neutral opinion toward CAI. In summary, a score between 42 and 126 would indicate an unfavorable opinion toward CAI, the lower the score the more unfavorable the opinion, and a score between 126 and 210 would indicate a favorable opinion toward CAI, the higher the score, the more favorable the opinion.

However, it must be emphasized that these interpretations are true only in the general case. For example, based on a sample size of 150 subjects, only 3 of them have scored below 126. It is possible that this instrument at this stage of development is incapable of detecting negative opinions.

Administration

While students were taking the course Elmath a sign was posted instructing the students to sign on to SOS (Student Opinion Survey) between chapters 8 and 10. Of the 127 students who completed Elmath, 116 followed the instructions. Because of machine malfunctions, data were not available for 27 students. The resulting total of 89 students provided the data for this report. Of the 89 students, 15 students were high-school teachers, 54 students were elementary teachers and the remaining 20 students were from a variety of other education occupations. In all cases the students were told to be frank, that there was no one right answer to a question and that their opinion would be kept confidential.

Results

The coefficient alpha reliability of SOS as determined from the data collected in Dryden, Virginia, was .84 which compares favorably with data collected at Penn State. The average obtained score was 154.29 with a standard deviation of 12.99. The range of scores was 64 points with the median score being 154.

The data were also divided into sub-groups. It was found that the high school teachers had an average SOS score of 153 (standard deviation = 16.51) the elementary teachers had an average SOS score of 155.1 (standard deviation 10.56) and the remaining subjects had an average SOS score of 152.9 (standard deviation = 16.54) (see Table 1).

Table 1

Means and Standard Deviation of the Student Opinion Survey for Various Groups

Group	N	$\bar{X}$	S.D.
Elementary Teachers	54	155.1	10.56
High School Teachers	15	153.0	16.51
Others	20	152.9	16.54
Total	89	154.3	13.07

An analysis was also performed to determine whether the amount of time required to complete Elmath was related to a person's opinion toward CAI. To accomplish this, the students were ranked according to the time to complete Elmath and then divided into four groups (see Table 2). An unweighted means analysis of variance procedure showed no significant differences between the groups indicating that time to complete Elmath was not related to a student's opinion (see Table 3).

Table 2

Means and Variance for Student Opinion Survey for Varying Instructional Time on Elmath

Instructional Time on Elmath	N	$\bar{X}$	Variance
12 - 16 hrs.	22	154.1	201.23
17 - 20 hrs.	23	154.3	181.04
21 - 26 hrs.	22	151.9	248.94
27 - 44 hrs.	22	156.9	62.89

Table 3

Analysis of Variance
Summary Table

Source	df	Sums of Squares	Mean Squares	F	P
Instructional Time	3	274.29	91.43	<1.0	
Error	85	14757.1	173.61		

Summary

The overwhelming majority of students expressed favorable opinions toward computer-assisted instruction after having been given an experience with the course. Only one person may be considered to have expressed a slightly unfavorable opinion toward CAI and two persons expressed a neutral opinion toward CAI. The remaining 86 students expressed favorable opinions toward CAI. These opinions were not influenced by education occupation or by the amount of time required by the student to complete the course. On the basis of these results alone, one may infer that the students were highly motivated to learn. It may also be inferred that these students would be willing to take further instruction via computer-assisted instruction.

In summary, the results of this student opinion survey indicate that for this population of students CAI results in favorable opinions toward CAI.

REFERENCE

Brown, Bobby R. An instrument for the measurement of expressed attitude toward computer assisted instruction. In Semi-Annual Progress Report no. R-5, Experimentation with Computer-Assisted Instruction in Technical Education, Project No. 5-85-074 prepared by Harold E. Mitzel, et al., University Park: The Pennsylvania State University, December 31, 1966, pp. 95-104.

APPENDIX

STUDENT OPINION TOWARD COMPUTER-ASSISTED INSTRUCTION

1. The method by which I was told whether I had given a right or wrong answer became monotonous.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

2. No one really cared whether I learned or not.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

3. I felt challenged to do my best work.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

4. I felt isolated and alone.

All the time	Most of the time	Some of the time	Only occasionally	Never

5. I felt as if someone were engaged in conversation with me.

All the time	Most of the time	Some of the time	Only occasionally	Never

6. As a result of having studied by this method, I am interested in learning more about the subject matter.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

7. I was more involved in running the machine than in understanding the material.

All the time	Most of the time	Some of the time	Only occasionally	Never

8. The learning was too mechanical.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

9. I felt as if I had a private tutor.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

10. The equipment made it difficult to concentrate on the course material.

All the time	Most of the time	Some of the time	Only occasionally	Never

11. The situation made me quite tense.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

12. Computer-asssisted instruction, as used in this course, is an inefficient use of the student's time.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

13. My feeling toward the course material after I had completed the course was favorable.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

14. I felt frustrated by the situation.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

15. I found the computer-assisted instruction approach in this course to be inflexible.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

16. Material which is otherwise interesting can be boring when presented by CAI.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

17. I was satisfied with what I learned while taking the course.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

18. In view of the amount I learned, this method seems superior to classroom instruction for many courses.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

19. I would prefer computer-assisted instruction to traditional instruction.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

20. This is just another step toward de-personalized instruction.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

21. I was concerned that I might not be understanding the material.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

22. The responses to my answers seemed appropriate.

All the time	Most of the time	Some of the time	Only occasionally	Never

23. I felt uncertain as to my performance in the programmed course relative to the performance of others.

All the time	Most of the time	Some of the time	Only occasionally	Never

24. I was not concerned when I missed a question because no one was watching me anyway.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

25. I found myself just trying to get through the material rather than trying to learn.

All the time	Most of the time	Some of the time	Only occasionally	Never

26. I knew whether my answer was correct or not before I was told.

All the time	Most of the time	Some of the time	Only occasionally	Never

27. In a situation where I am trying to learn something, it is important to me to know where I stand relative to others.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

28. I guessed at the answers to some questions.

All the time	Most of the time	Some of the time	Only occasionally	Never

29. I was aware of efforts to suit the material specifically to me.

All the time	Most of the time	Some of the time	Only occasionally	Never

30. I was encouraged by the responses given to my answers of questions.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

31. In view of the time allowed for learning, I felt too much material was presented.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

32. I put in answers knowing they were wrong in order to get information from the machine.

All the time	Most of the time	Some of the time	Only occasionally	Never

33. I felt I could work at my own pace.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

34. Questions were asked which I felt were irrelevant to the material presented.

All the time	Most of the time	Some of the time	Only occasionally	Never

35. The flickering screen did not annoy me.

All the time	Most of the time	Some of the time	Only occasionally	Never

36. Material which is otherwise boring would be interesting presented this way.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

37. I could have learned more if I hadn't felt pushed.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

38. I was given answers but still did not understand the questions.

All the time	Most of the time	Some of the time	Only occasionally	Never

39. The material was presented too slowly.

All the time	Most of the time	Some of the time	Only occasionally	Never

40. The responses to my answers seemed to take into account the difficulty of the question.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

41. While on computer-assisted instruction, I encountered mechanical malfunctions.

All the time	Most of the time	Some of the time	Only occasionally	Never

42. Computer-assisted instruction did not make it possible for me to learn quickly.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

CURRICULUM REVISIONS

Cecil R. Trueblood, Diane Knull, and Elizabeth Elliott

Since the computer can automatically record and store all or selected student responses and response times, the instructors or course authors can later obtain a print-out of this student record data by means of special instructions. The purpose of this report is to indicate the type and number of curriculum revisions which were made based on the analysis of student records and on-site observations.

The following procedures were used to determine what curriculum revisions might be made. A request was made for a one-line summary of student performance for each frame in the course. See Table 1 for an example of the types of data contained in the one-line summary.

Table 1

One-line Summary

Ep Identifier	Students	Attempts	% Attempts > 2	Mean Latency
D62x1	2	10	50	5.00
D62x2	2	3	0	1.50
D62x3	2	4	50	2.00
D65	10	14	9	1.40

The data in the one-line summary were analyzed to determine which questions might be causing students difficulty. For any frame where the mean number of attempts was greater than two, another request was made to obtain detailed student records. See Table 2 for an example of the types of data contained in this summary.

Using the data in the detailed student records and the original program, the authors determined whether a revision of course content or Coursewriter II instructions might improve student performance. The number and types of revisions made are shown in Table 3 and discussed on the following page.

Table 2

Student Records

Course	Seq.	S	Ep	Ident.	Match	Attempts
Elmat	4	YAMG		D65	UU	1
	Responses - 1111010					
Elmat	4	YAMG		D65	UU	2
	Responses - 1111010					
Elmat	4	YAMG		D65	CC	3
	Responses - 1011010 (two)					

Table 3

The Type and Number of Curriculum Revisions

Type of Curriculum Revisions	Number of Revisions
WA Feedback	38
CA Feedback	7
UN Feedback	16
Context	26
Branch	9
Image Reel	19
Function	125
LP Responses	7
Op Code	11
Student Handbook	12

Unanticipated Answers (WA, CA, and UN Feedback)

This type revision was made when students gave correct or incorrect answers which had not been anticipated by the authors and received inappropriate feedback. A comparison of lines 11 and 16 on the following printouts (Fig. 1 and Fig. 2) illustrate how these frames were revised to provide appropriate feedback. Line 11 shows that students will now receive appropriate feedback for the WA's "count" and "number." Line 16 shows that the answers "one-to-one" and "1-to-1" will now be given correct answer feedback.

```
1  pr
2  de  0/32
3  dt  0,0/6,0/40,0/Readiness for studying cardinal number
       of sets can begin with each child using
       a small flannel board and the
4  dt  ,0/2,/40,0/materials shown on the image projector.
5  fpl 27
6  dt  ,0/4,/40,0/What should the teacher ask pupils to do
       if they can't find any likenesses?
7  ep  16,0/2,16/40,0//99/1x17
8  fn  ed//b0,d//^
9  de  24/8
10 aa  */aa
11 ld  .match.pair.corres.compar/b2
12 fn  mk///.
13 fn  es/nw/1/.///c
14 dt  24,0/4,24/40,0/Good. After pairing they recognize that
       for each boy there's a ball.
```

Fig. 1. Frame print-out before revision.

```
1  pr
2  de  0/32
3  dt  0,0/6,0/40,0/Readiness for studying cardinal number
       of sets can begin with each child using
       a small flannel board and the
4  dt  ,0/2,0/40,0/materials shown on the image projector.
```

Fig. 2. Frame print-out after revision.

Fig. 2 (continued)

```
5  fpl 27
6  dt  ,0/4,/40,0/What should the teacher ask pupils to do
   if they can't find any likenesses?
7  ep  16,0/2,16/40,0////1x17
8  fn  ed//b0,d// ^
9  de  24/8
10 aa  */aa
11 ld  count number/b2
12 fn  mk///^
13 fn  es/nw/1/^///w
14 dt  24,0/4,24/40,0/What type of correspondence would help?
15 aa  */aa
16 ld  .match.pair.corres.compar.1to1.onetoone.b2
17 fn  mk///.
18 fn  es/nw/1/.///c
19 dt  24,0/4,24/40,0/Good. After pairing they recognize that
   for each boy there's a ball.
```

Fig. 2. Frame print-out after revision.

Context Revisions

This type revision was necessary when the wording in either initial questions or possible answers delayed student progress. In the following example, student record analysis indicated that the initial question was too general to elicit the specific terms desired. An examination of lines 3 and 4 in the following frame print-outs (Fig. 3 and Fig. 4) indicates what text was added to get students to consider two specific types of sets.

```
1  prr
2  de  0/32
3  dt  2,0/6,2/40,0/After numerous matching exercises the
   teacher should be able to introduce the
   children to what type of sets?
```

Fig. 3. Frame print-out before revision.

```
1 prr
2 de  0/32
3 dt  2,0/6,2/40,0/After numerous matching exercises the
      teacher should be able to introduce the
      children to what type of sets?  Type
4 dt  ,0/2,/40,0/either equal or equivalent.
```

Fig. 4. Frame print-out after revision.

Branch Revisions

These revisions were made when student records indicated that some students could advance more rapidly or that some students needed additional instruction. In the following case, student records indicated that if a student correctly answered question c06, he did not need the additional examples in the branch c06x1 and c06x2. The program was revised as indicated in the following flow charts (Fig. 5) so that students who correctly answer c06 go directly to c07.

Image Reel Revisions

For several questions student records and on-site observations indicated that the content of the accompanying image reel frames was impeding student progress. In these cases, students had difficulty identifying the correct answers to questions because the accompanying image reel frames were not labeled. The revision was simply to label the objects on those images. After all revisions for a reel were made, the complete image reel was rephotographed.

FN Revisions

These function revisions made the program more sophisticated in that it allowed and accepted more varied responses from the students. In the following example (Fig. 6), the addition of the edit function in line 5 takes out spaces, parentheses, and the correct base subscript. In the revised form (Fig. 7) if the student answers with any combination of spaces, parentheses, and the correct base subscript, his answer will be accepted.

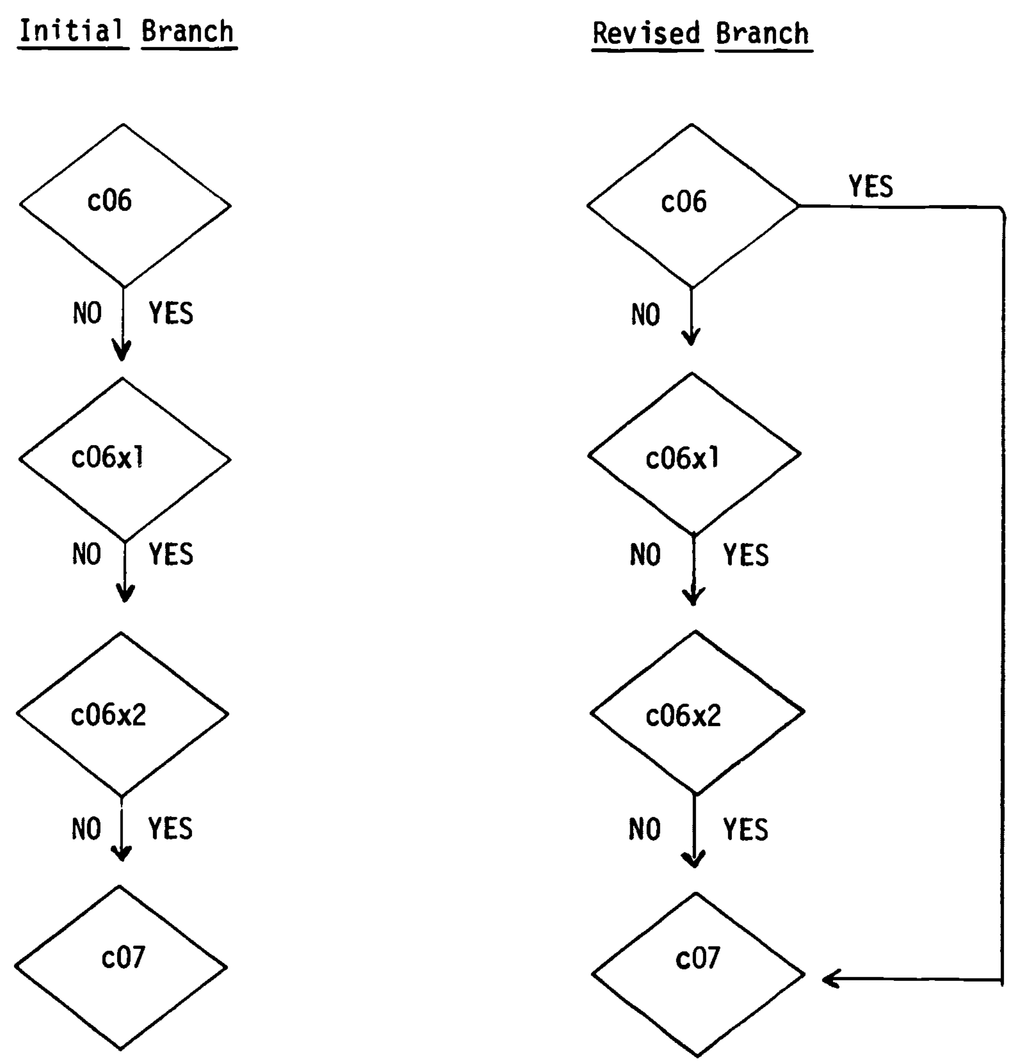

Fig. 5. Flowcharts of program frame showing initial branch and revised branch.

```
1 prr
2 de  0/32
3 dt  0,0/2,0/40,0/What is 724 (ten) in base eight?
4 ep  2,0/2,2/40,0//99/d18
5 aa  *
6 ld  1324/b2
```

Fig. 6. Frame print-out before revision.

Fig. 6 (continued)

```
 7  fn  mk///∧
 8  fn  es/nw/1/∧///c
 9  dt  16,0/2,16/40,0/Correct.  724(ten) = 1324(eight).
10  pa  20
11  br  d19
12  un  un
13  de  16/2
14  dt  16,0/2,16/40,0/Incorrect.  Let's try some smaller steps.
15  pa  20
16  br  d18x1
```

Fig. 6. Frame print-out before revision.

```
 1  prr
 2  de  0/32
 3  dt  0,0/2,0/40,0/What is 724(ten) in base eight?
 4  ep  2,0/2,2/40,0//99/d18
 5  fn  ed///∧/(/)/eight
 6  ca  1324/cc
 7  de  16/2
 8  dt  16,0/2,16/40,0/Correct.  724(ten) = 1324(eight).
 9  pa  20
10  br  d19
11  un  un
12  de  16/2
13  dt  16,0/2,16/40,0/Incorrect.  Let's try some smaller steps.
14  pa  20
15  br  d18x1
```

Fig. 7. Frame print-out after revision.

In some cases the student's typing caused him to receive the feedback for an unidentified answer. For example, before an appropriate edit function was added, the response "FOUR" was not accepted as a correct answer; therefore, the edit function in line 5 (Fig. 8 and Fig. 9) was used to downshift all capital letters and to take out all spaces.

```
 1  prr
 2  de  0/32
 3  dt  0,0/6,0/40,0/Consider the letters in the word "card."
    How many members or elements are in
    this set of letters?
 4  ep  8,0/2,8/40,0//99/a3
 5  de  16/16
 6  ca  4/cc
 7  cb  four/cc
 8  dt  16,0/2,16/40,0/4 is correct.
 9  pa  20
10  un  un
11  dt  16,0/6,16/40,0/The word "card" has four letters.  How
    many elements would this be?  Now answer
    again.
12  un  un
13  dt  16,0/6,16/40,0/"Card" contains 4 letters.  Therefore,
    there are four elements in this set
    of letters.  Type 4.
```

Fig. 8. Frame print-out before revision.

<u>OP Code Revisions</u>

The need for OP code revisions to gain the desired course affect was determined from on-site observations.

One PA (pause) revision altered the length of pause between multiple light pen responses. This revision was necessary to keep students from becoming confused about whether or not the computer had accepted their

```
1  prr
2  de  0/32
3  dt  0,0/6,0/40,0/Consider the letters in the word "card."
   How many members or elements are in
   this set of letters?
4  ep  8,0/2,0/40,0//99/a3
5  fn  ed//b0,d//∧
6  de  16/16
7  ca  4/cc
8  cb  four/cc
9  dt  16,0/2,16/40,0/4 is correct.
10 pa  20
11 un  un
12 dt  16,0/6,16/40,0/The word "card" has four letters.  How
   many elements would this be?  Now answer
   again.
13 un  un
14 dt  16,0/6,16/40,0/"Card" contains 4 letters.  Therefore,
   there are four elements in this set
   of letters.  Type 4.
```

Fig. 9. Frame print-out after revision.

first choice and was prepared to accept their second choice. Also, if the student responds with a wrong answer, the computer now (1) erases any previous feedback, (2) pauses, (3) gives the new feedback, (4) pauses, and allows the student to begin his next attempt.

The OP code revisions also include: (1) changing an EP (enter and process) to give students more space to answer questions, (2) inserting an EP when there wasn't one so that students can answer, (3) inserting a UN (unrecognized answer) to correct the flow of the program, and (4) inserting a PR (problem start) at the beginning of a frame.

The omission of the PR in the example frame (Fig. 10) affected the course flow in that students received the frame labeled c21 before they had correctly answered c20. The addition of the PR in line 1 of the revised frame (Fig. 11) corrected this problem.

```
1  de  0/32
2  dt  0,0/6,0/40,0/Instead of writing out, for example,
       "3 hundreds + 4 tens + 7 ones," we might
       use a chart like this:
3  pa  60
4  dti 7,0/2,7/40,0/Hun-
5  dti 9,0/4,9/15,0/dreds  Tens  Ones
6  dti 8,17/2,8/23,17/Numerals  Word name
7  dti 13,3/2,13/20,3/3    4    7    347
8  dti 12,27/2,12/13,27/three hundred
9  dti 14,27/2,14/13,27/forty-seven
10 pa  60
11 dti 18,3/2,18/12,3/3    6    7
12 dti 17,27/2,17/13,27/three hundred
13 dti 19,27/2,19/13,27/sixty-seven
14 epi 18,20/2,18/3,20//3/c21
15 ca  367/cc
16 dt  24,0/2,24/40,0/Yes.  367 = 3 hundreds + 6 tens + 7 ones.
17 pa  50
18 de  24/2
19 br  prl
20 un  un
21 dt  24,0/2,24/40,0/No, try again.
22 pa  30
23 un  un
24 dt  24,0/2,24/40,0/The numeral is 367.  Type 367.
25 pa  30
```

Fig. 10. Frame print-out before revision.

```
1  pr
2  de  0/32
3  dt  0,0/6,0/40,0/Instead of writing out, for example,
   "3 hundreds + 4 tens + 7 ones," we might
   use a chart like this:
4  pa  60
5  dti 7,0/2,7/40,0/Hun-
6  dti 9,0/4,9/15,0/dreds  Tens  Ones
7  dti 8,17/2,8/23,17/Numerals  Word name
8  dti 13,3/2,13/20,3/3    4    7   347
9  dti 12,27/2,12/13,27/three hundred
10 dti 14,27/2,14/13,27/forty-seven
11 pa  60
12 dti 18,3/2,18/12,3/3    6    7
13 dti 17,27/2,17/13,27/three hundred
14 dti 19,27/2,19/13,27/sixty-seven
15 epi 18,20/2,18/3,20//3/c21
16 ca  367/cc
17 dt  24,0/2,24/40,0/Yes.  367 = 3 hundreds + 6 tens + 7 ones.
18 pa  50
19 de  24/2
20 br  prl
21 un  un
22 dt  24,0/2,24/40,0/No, try again.
23 pa  30
24 un  un
25 dt  24,0/2,24/40,0/The numeral is 367.  Type 367.
26 pa  30
```

Fig. 11. Frame print-out after revision.

<u>Student Handbook Revisions</u>

Revisions in the Handbook included correction of a few typographical and content errors and inclusion of omitted pages. Student reaction and on-site observation were also used to make improvements in the second printing of the Handbook currently under way.

COMPUTER SYSTEM OPERATION AND UTILIZATION

Stanley Mechlin and Harry Maurer

Overall Terminal Utilization

Terminals were used exclusively for the Elmath course from 1:00 to 10:00 p.m. on weekdays and from 9:00 a.m. to 4:00 p.m. on Saturdays. During the first 40 days of operation at Dryden, terminal utilization during the Elmath periods was approximately 65% of the available time. Utilization was lower during the period of 1:00 to 4:00 p.m. on weekdays because the students were teaching school and were not available. Consequently, utilization during the "prime time" (4:00 to 10:00 p.m.) was probably 80 to 90%. While students were registering for the course during the first week of operation, utilization was below 50%, which tends to distort the overall figure of 65%. If the first week were discounted, overall utilization would have been approximately 70%. The percentage of utilization could have been higher if more students had been available, although 100% utilization is not realistic because of illnesses and other occurrences. The system was also used for numerous demonstrations, outside of the Elmath periods described above. These demonstrations have not been included in the utilization figures cited above.

1500 Instructional System Performance

During the eight weeks that the computer system was in operation at Dryden the overall performance of the system was very good. There were only a few short "down times," three of which were due to power failures in the community and one due to operator error. The total time lost was 740 "student minutes" (student minutes of 30 means 1 minute each for 30 students or 30 minutes for 1 student or any combination between). Dividing the 740 student minutes lost by the 129 students who completed the course means that each student who completed the course had his instruction interrupted for less than 6 minutes during the eight-week period. This small amount of student time lost would appear to be very minor in view of systems downtimes on former prototype systems for CAI. The lost time is also negligible when considered against the amount of time lost in a conventional classroom.

Terminal Down Time

Repair logs indicate 17 individual terminal failures during the first 23 days of operation. Since such logs are rarely complete, it is probably safe to assume about one terminal failure per day with terminal down times ranging from a few minutes to several hours. Both Penn State operating personnel and the IBM Customer Engineer at the Dryden site suggest that one terminal should remain unscheduled at all times to provide backup in case of terminal breakdown.

System Response Time

At various times the system response time was checked. This was accomplished by means of a program called TIMEHEX which initiated a series of ten (10) responses on the system and then computed the average delay on the system. Sampling was done from April 25, 1969, to May 3, 1969. The duration of the sample varied from 20 minutes to 1 hour and 30 minutes between the hours of 2:00 p.m. and 9:00 p.m. with the exception that on May 3, 1969, the sample was made from 9:17 a.m. to 10:15 a.m. Average response time computed was 0.4 seconds with a range of 1.6 seconds.
Delays over 1.0 seconds were caused by students signing on or off the course. The number of students signed on the course while response time was being tested varied from 4 to 14 students. The course material was contained on two disk packs with students taking course material from various parts of both disks. At various times all of the students were using only one disk without any increase in the delay on the system.

```
station   09[a]  timehex[b]   proctor message[c]
               Delay = 0.7[d]  seconds.  Time = 21:12.[e]
station   09     timehex      proctor message
               Delay = 0.2   seconds.  Time = 21:13.
station   09     timehex      proctor message
               Delay = 0.2   seconds.  Time = 21:14.
```

Fig. 1. Sample of Messages from the Program TIMEHEX

[a]station number at which the timing program is being executed
[b]name of program being executed
[c]type of message
[d]computed system delay for ten responses
[e]actual time of message (24 hour clock)

Table 1

Summary of Output from Timing Program

No. of Students On Line	System Delay in Seconds	Time	Date
4	0.5	13:47	1 May 69
4	0.1	13:48	1 May 69
5	1.3	13:49	1 May 69
5	0.1	13:50	1 May 69
13	0.2	15:45	28 Apr 69
14	0.7	15:46	28 Apr 69
14	0.4	15:47	28 Apr 69
14	0.6	16:03	28 Apr 69
14	0.1	16:04	28 Apr 69
12	0.5	20:14	2 May 69
12	0.3	20:15	2 May 69
12	0.2	20:16	2 May 69
12	0.2	20:17	2 May 69
11	0.3	20:18	2 May 69
5	0.1	9:17	3 May 69
5	0.3	9:17	3 May 69
5	0.1	9:18	3 May 69
6	0.5	9:19	3 May 69