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ABSTRACT

The school districts of Pittsburgh and Philadelphia, the Department of Education of the Commonwealth of Pennsylvania, and Pennsylvania State University formed the Computer-Assisted Instruction Consortium to develop and evaluate two high school mathematics programs utilizing the medium of computer-assisted instruction. The first 18 months of the project (until fall of 1969) was spent in curriculum development activities. A full-year trial of the materials provided feedback for course revision and blocking of exercises into units. During the school year 1970-71 the Consortium worked on a major evaluation effort, dissemination activities, and polishing the curriculum materials in general mathematics and algebra. The predominant theme for the curriculum was teacher-monitored independent study for each student. Two main types of material composed the individual study curriculum: an "on-line" or computer-mediated component involving student/content interaction at the computer terminal and an "off-line" component consisting of self-study in a variety of modes, such as workbooks, filmstrips, puzzles, games, and textbooks. Both the general mathematics and the algebra material was designed to appeal to urban youth. The course development, summative evaluation, and a cost analysis of the system are presented along with summaries of the courses and the materials prepared for them. (JY)

C·A·I

COMPUTER ASSISTED INSTRUCTION LABORATORY

COLLEGE OF EDUCATION · CHAMBERS BUILDING

THE PENNSYLVANIA STATE UNIVERSITY · UNIVERSITY PARK, PA.

A COMMONWEALTH CONSORTIUM TO DEVELOP, IMPLEMENT AND EVALUATE A PILOT PROGRAM OF COMPUTER-ASSISTED INSTRUCTION FOR URBAN HIGH SCHOOLS

Final Report

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Marilyn N. Suydam
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Report No. R-47

July 1971

The Pennsylvania State University

Computer Assisted Instruction Laboratory
University Park, Pennsylvania

Final Report

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CHAPTER I

THE DEVELOPMENT AND EVALUATION OF TWO COMPUTER-BASED PROGRAMS IN HIGH SCHOOL MATHEMATICS

Harold E. Mitzel

It is clear from a study of the provisions of the Elementary and Secondary Education Act of 1965 that the authors of the legislation were concerned with the early implementation of innovative practices in the schools. These new practices were to be designed, tested, and implemented to make a long-term contribution to the improvement of educational quality. The legislation pointed to the fact that the schools could not be greatly improved by a policy of "more-of-the-same" or "business-as-usual."

To be maximally effective, change, of the type sought in the legislation, must be undergirded with new theoretical constructs which provide both a foundation and a launching platform for long-term improvements.

This belief was the spirit which guided the formation of the Commonwealth Computer-Assisted Instruction Consortium by the School Districts of Pittsburgh and Philadelphia, the Department of Education of the Commonwealth and The Pennsylvania State University. By merging the talents of their respective staffs and using the pragmatic opportunities offered for educating urban children, the Consortium was formed to develop and evaluate two high school mathematics programs utilizing the medium of computer-assisted instruction.[1] The reader is referred to the conference report edited by Levien for an assessment of the unique role of the non-profit consortia as a source of technology-based curriculum materials.[2]

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[1]Mitzel, H. E., and Bost, W. A. "New Models for Implementing Technology in Education." In Morphet, E. L. and Jesser, D. L. (Eds.), Designing Education for the Future. Project Office, Denver, Colorado (1968).

[2]Mitzel, H. E. "Preparation of Instruction Materials by Non-Profit Consortia." In R. E. Levien (Ed.), Computers in Instruction. Rand Corporation, Santa Monica, California (July 1971).

It is well known among educators that most attempts to individualize instruction have either had such limited objectives as to be trivial or have failed for lack of an adequate supporting technology. The affinity of American schools for the self-contained classroom of 30 pupils and a teacher has been a response born out of both economic necessity and a lack of knowledge of a better way to meet mass education objectives. The modern digital computer, less than 25 years old, has provided educators with the first glimmer of opportunity for changing the process and the procedures inherent in mass education for the last two centuries.

Space does not permit a repetition of the rationale for choosing the computer as a means of achieving the goal of adaptive education, but the reader is referred to articles by Mitzel.[3, 4]

The Commonwealth CAI Consortium was initially funded by the U. S. Office of Education on March 16, 1968, under the provisions of Title III of the Elementary and Secondary Education Act. The purpose of the organization was to develop and evaluate two individually-adaptive mathematics courses for urban high school youth. Because Pennsylvania ninth-graders typically take either general mathematics or a first course in algebra, it was decided to construct both courses so that they would be the beginning of the building of a complete four-year secondary mathematics program. Some students, of course, take general mathematics followed by algebra in order to avoid being stereotyped into a non-college general high school curriculum.

The "game-plan" for the project was to spend the first 18 months (or until Fall 1969) in curriculum development activities. The school year 1969-70 was planned as a full-year field trial of the materials developed to that point with a limited number of students. Feedback from the pupils to the curriculum development team, provided the basis for course revision and blocking

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[3]Mitzel, H. E. "Computers and Adaptive Education." American Education, 60(7):749-754, (December 1970).

[4]Mitzel, H. E. "The Impending Instruction Revolution." Phi Delta Kappan, 51(8):434-439, (April 1970).

of exercises into units. The just-completed school year 1970-71 was designed as the time for a major evaluation effort, for dissemination activities, and for polishing the curriculum materials in general mathematics and algebra.

Building a new curriculum by employing a radically different technology, such as computer-assisted instruction, requires careful definition of a plan for implementing the new combination of curriculum and technology with students. The utilization pattern for the Consortium was conceived as an individually-adaptive set of mathematics experiences. The predominant theme was teacher-monitored independent study for each student. Drastically curtailed was the traditional approach to mathematics instruction with its emphasis on teacher exposition and student recitation around textbook themes.

Two main types of material composed the individual study curriculum: an "on-line" or computer-mediated component involving student/content interaction at a computer terminal and an "off-line" component consisting of self-study in a variety of modes, such as workbooks, filmstrips, puzzles, games, and textbooks. The on-line program provided the principal source of continuity within the total curriculum, and the two types of materials were correlated by means of inserting definite, carefully-selected off-line assignments at strategic points in the computer-mediated program. In general the on-line material was programmed to be the basics or fundamentals of each subject and the off-line sequences served as enrichment and remedial functions with emphasis on enrichment.

The utilization plan for the project called for use of the existing eight-period school day (45 minutes per period), with about twice as many pupils as terminals assigned to each period. Put another way, the pupil making average progress was expected to spend about one-half-time in on-line and one-half-time in off-line study. With close teacher-monitoring provided for in the utilization pattern, bright, quick students were supposed to spend somewhat less than the average one-half period per day with the on-line fundamentals and the slower students somewhat more than one-half-time at the computer terminals. These plans were modified in practice in the schools during the last year of the project in order to adapt to local needs. Details of this modification are provided in later sections of this report.

A special effort was made to design both general mathematics and algebra content which would appeal to urban youth. Examples of mathematics applications as close as possible to the real-life experiences of youngsters in cities were sought by the developers.

Schenley High School in Pittsburgh and Lincoln High School in Philadelphia were chosen in advance as sites for field trial and evaluation efforts for Consortium activities. The Computer Assisted Instruction Laboratory at Penn State was the major site for curriculum development activities and for technical development in computer education srrategies.

The work of the Consortium was carried out under a grant to the School District of Pittsburgh as the sponsoring local educational agency, or LEA, with sub-contracts to the Philadelphia School District and to The Pennsylvania State University. An operating committee which monitored the Consortium activities was composed of Dr. Charles Hayes, Chairman, for Pittsburgh Schools; Dr. Sylvia Charp, for Philadelphia Schools; Mr. Carl Heilman, for Department of Education, and Professor Harold E. Mitzel, for Penn State. Policy matters were the province of an Advisory Group composed of one executive from each of the sponsoring organizations. The members were Dr. Mary Molyneaux, Assistant Superintendent, Pittsburgh Schools; Dr. Robert Rossheim, Executive Director of Information Processing, Philadelphia Schools; Dr. Donald Carroll, Assistant Commissioner, Department of Education; and Dean A. W. VanderMeer, College of Education, The Pennsylvania State University.

CHAPTER II

COURSE DEVELOPMENT

Robert V. Igo and Lars C. Jansson

Organization

A computer-assisted instruction (CAI) course has two components: 1) an instructional program and 2) a computer program. An instructional program contains the content of instruction and a set of decision rules for sequencing events (i.e., strategies) executed during instruction. The responsibility for developing an instructional program belongs to a course author. Computer programs, written by programers, mediate the instructional program at a computer terminal. For the Consortium courses, authors and programers were organized into teams to develop the ALGEB and GENMA courses.[1]

Each team consisted of two course authors and two programers, assisted by a graduate assistant. Two teachers from each of the two participating school districts assumed the role of course author, with one teacher from each district assigned to a course development team. Team assignments were made on the basis of the teachers' experience with the subject.

The course programers were members of the Penn State CAI Laboratory staff, three having had training and experience as mathematics teachers. This teaching experience proved valuable in assisting the course authors with debugging and revising the instructional program.

A mathematics educator from the College of Education at Penn State provided guidance for the course authors in developing the scope and sequence of the course materials and in selecting appropriate strategies. The mathematics educator also monitored the program as it developed.

Course development was coordinated by a member of the Penn State CAI Laboratory staff who had experience as a classroom teacher and the various aspects of CAI. Technical support was provided by members of the computer system staff of the CAI Laboratory.

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[1]The algebra and general mathematics courses developed for CAI were referred to as ALGEB and GENMA respectively.

The Computer System

The IBM 1500 computer system used in this project is designed specifically as an instructional system. A computer terminal (or student station) consists of three display/response devices which may be used individually or in combination. The central display device is a cathode-ray tube screen (CRT) 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. One response device is a typewriter-like keyboard which makes possible constructed responses by typing the necessary characters. A second response device, the light pen, permits response to displayed text, figures, and graphics, by touching the appropriate place on the screen. An image projector, utilizing 16mm film, is capable of holding 1024 colored and/or black and white images on a single reel. This device, under program control, can access 40 images per second. An electric typewriter is a separate output unit used to deliver messages regarding student performance in the program. It may also be used for input by a proctor to relocate students within the program.

The 1500 system is capable of accommodating up to a total of 32 terminals, each complete with the CRT and image projector devices. A pictorial diagram of the 1500 system may be found in Appendix A.

Development Procedures

Prior to beginning course development, the teachers were oriented to the techniques and the underlying philosophy and theories for preparing instructional programs. They were introduced to Coursewriter II, the computer language used in writing programs for the IBM 1500 system (see Appendix B). A knowledge of the computer language was not necessary for writing the instructional programs, although it was helpful in the field trial and evaluation phases of the project when minor changes to the computer program were made at the schools.

The initial phase of course development included 1) determining the scope and sequence, 2) writing entry requirements and behavioral objectives, and 3) identifying instructional strategies for the program. The courses of study for algebra and general mathematics from the Philadelphia and Pittsburgh schools provided guidelines for developing the scope and sequence of the two CAI courses. Before proceeding with CAI course development, the proposed content was submitted to the mathematics coordinators of the participating schools for their approval.

The utilization plan for the Consortium project called for students to receive initial instruction and some practice with the course content on-line. Practice exercises and supplemental materials were to be assigned as off-line activities. Since the off-line activities were to be articulated with the on-line instruction, the course authors were responsible for identifying the off-line activities concurrent with writing the instructional programs.

The main phase of course development included writing the instructional programs. Each course author assumed responsibility for the materials in specific chapters of the course. Their primary task associated with the on-line program was authoring text material, questions, and student feedback. The material was written by the authors on a paper form that permitted the text to be put in the format that would appear on the CRT screen. Instructions regarding the sequence in which text was to appear on the screen, the responses to be accepted, and the criterion for branching from the main course-flow were written in the margins of the forms.

Forms prepared by a course author were given to a programer who determined the logic necessary to implement the instructional program. The operational codes (instructions to the computer) were then added to complete a course program. The information on the coded forms was transferred to data cards. These cards were then submitted to a system operator who loaded the deck (of cards) into the computer where the information from the cards was assembled and stored in a disk file.

Each newly-assembled program was checked for errors, i.e., debugged. The programer responsible for input would execute the program, looking for errors in program execution, in screen formating, or in grammatical and mathematical content. The course author, who wrote the material, would check completed sections of the program for mathematical (content and textual) errors. The mathematics educator and curriculum coordinator checked completed chapters for mathematical accuracy and consistency of terminology and instructional strategies. Detected errors were corrected on-line by the programer.

To provide consistency within the instructional programs, certain conventions were established by common agreement among the course authors. For example, conventions were adopted regarding the use of 1) response modes (multiple-choice or constructed), 2) response devices (light pen or keyboard), 3) medium (CRT screen or image projector), and 4) CRT screen formating. Multiple-choice items were utilized when the response required was the discrimination between positive and negative instances of a concept. Constructed responses were used with the application or identification of a concept. Responses to multiple-choice items were made by light pen; constructed responses by keyboard. Rules, summary information, and pictorial representations were displayed via the image projector. Centering and spacing text, proving response areas and use of animation were considered when displaying information on the CRT screen.

The programers were able to develop their own conventions and programing techniques as the course authors adopted conventions and developed patterns of writing instructional frames. Macros[2] were used extensively. The programers also developed special routines that were used repeatedly throughout both courses (see Appendix C).

The Instructional Program

The original version of each course was organized to accommodate the utilization plan referred to earlier. The on-line materials were developed in sections (or blocks) which included both introductory and practice materials. It was assumed that a student would remain on-line during a class period until a section was completed. An assignment of an off-line activity, designed to supplement the on-line instruction, was made at the end of each

[2] A macro is a programing device that permits repeated use of one programing logic. Macros are available on call by the computer when a program is loaded into the computer.

section, as a student signed off. An off-line assignment was to be completed in the classroom. When the student next signed on, presumably the following school day, an option to review the material covered during the previous terminal session was given. If the option was taken, a brief summary of the material in the previous section was provided prior to proceeding to the next section. If the option was not taken, the program started with the next section.

Testing. No systematic evaluation of student progress through the on-line material was made within the chapters of the courses in the original versions. However, a review of the instructional material within a chapter and a chapter test were administered on-line at the end of each chapter. (A chapter review test and a chapter test are described in Appendix C.)

Drill materials. Adjunct, on-line drill materials were developed for the general mathematics course. These short programs provided drill in basic arithmetical operations. An attempt to make drill more "palatible" resulted in several programs having a game format. (See Appendix D).

Revised on-line programs. Early in the field trial phase of the project, the CAI classroom teachers reported that the structure of both the ALGEB and GENMA courses needed to be revised. The quantity of material in sections of the on-line program was judged excessive and conversely the quantity of off-line materials was deemed inadequate. Members of the Consortium staff at Penn State, consulting with the teachers in the CAI classrooms in Pittsburgh and Philadelphia, reorganized the structure of both courses. Materials in each chapter were organized into instructional blocks. The format of an instructional block was designed to provide a flexible learning situation, i.e., entry requirements were checked with a preskills test, an opportunity to skip specific quantities of instruction were provided by a pretest, and a summary emphasized the main points of the instruction within a block. Student progress was evaluated by a criterion-referenced test ("out quiz").

Off-line Assignments. Assignments were placed in three categories (A, B, and C) according to their utility. Category 'A' assignments were designed to supplement the on-line instruction. All students who completed the instruction, practice and/or summary within a block received an 'A' assignment. Assignments in the 'B' category contained remedial materials. 'B' assignments were made when a student failed to meet criterion on a second iteration of an "out quiz." Category 'C' assignments were intended as enrichment exercises for students who moved rapidly through the on-line program.

In the ALGEB course, 'A' assignments were made from the text[3] adopted by the teachers, primarily for the purpose of providing practice exercises. Since the GENMA team was unable to find a suitable text, the 'A' assignments were written by the GENMA authors as they wrote the program.

The materials for the 'B' assignments included filmstrips, printed programed material, and other commercially available materials.

The 'C' assignments also consisted of commercial materials, most often consisting of mathematical games and puzzles. Although materials on such topics as topology, probability, and number theory were available, the teachers reported that the students were unable to use them without considerable assistance.

A description of the algebra off-line program is given in Appendix E. A list of commercial materials suggested for use as off-line materials may be found in Appendix F.

Student performance information. As indicated earlier, the total CAI classroom program consisted of both on-line and off-line materials. Although the primary source of information for students in the ALGEB and GENMA courses was a computer-mediated program, the effectiveness of the total CAI instructional environment to provide optimum learning was viewed as the responsibility of the teacher in charge of that classroom. The level of self-direction in a learning situation for the ninth grade students assigned to the CAI classroom was not deemed adequate to attain the desired learning tasks without some assistance from a teacher. The responsibilities of a teacher managing the over-all program included: monitoring student progress through the on-line

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[3] Max, P. and Schaff, W. L. ALGEBRA, A Modern Approach, Book 1. (2nd Ed.) D. Van Nostrand, Princeton, New Jersey, 1968.

program, supplementing the on-line instruction when necessary, and organizing and administering the off-line materials to accommodate the needs of the individual students.

To facilitate the management of the total CAI classroom program, information on individual performance of the students was made available to the teachers by a computer program. As each student interacted with the computer-mediated instruction, information regarding the interaction was stored in the computer. A special computer program (the Student Performance Summary, or SPS) was developed to extract the stored information. The information, provided daily by the SPS program, included for each student:

1) the location of the course,
2) the time on line,
3) the number of quizzes taken,
4) the off-line assignment reference,
5) the chapter test scores, and
6) the number of days on line.

An example of the content of an SPS printout is provided in Appendix C.

Information provided by SPS was supplemented by proctor messages received, at a typewriter terminal, as the on-line program was executed. Proctor messages were produced by the Coursewriter program if a student: 1) failed on the second or third iteration of an out quiz, 2) failed a preskills test, 3) passed a pretest and subsequently skipped instruction, or 4) experienced difficulty with a particular concept during the course of instruction.

Formative Evaluation

Initial student reaction to the Consortium mathematics programs was obtained during the summer of 1969. Sixteen eighth grade students from the State College (Pa.) Area Schools participated in an abbreviated field trial at the Penn State CAI Laboratory. Eight students were assigned to the ALGEB course and eight to the GENMA course. The purpose of the trial run was to 1) observe student reaction to the on-line program, 2) develop procedures for program revision, and 3) provide the teacher-authors with experience in managing a CAI classroom.

The field-trial phase of the project was conducted during the 1969-70 school year. An IBM 1500 computer system with eight instructional stations was installed in Schenley High School at Pittsburgh. A similar system was installed in Lincoln High School at Philadelphia. The teachers who served as course authors at Penn State returned to their respective districts to manage the CAI classrooms. Sixteen students were assigned to a class period. Four classes of ALGEB and four classes of GENMA were scheduled in each school. The utilization plan described in Chapter I was implemented.

Due to personnel and time constraints, no attempt was made to evaluate the over-all effectiveness of instruction as a base for extensive revision of the instructional program. Revisions were confined to 1) computer programing errors, 2) presentation (e.g., screen format), grammatical and mathematical errors, 3) minor course changes, and 4) course organization.

Revisions were based on feedback from the teachers in the CAI classrooms and data accumulated and stored by the computer program on student performance during execution of the program. When programing and presentation errors were detected, the teachers informed the Penn State Consortium staff so that corrections could be made immediately in the program. Information from the teachers and the student performance data was used to make minor course changes such as the addition of synonymous correct responses, the rewording of questions and feedback, or the addition of feedback to wrong responses.

A meeting of the CAI classroom teachers from Lincoln and Schenley High Schools was held with the Penn State Consortium staff in February 1970. Three recommendations were made by the teachers: 1) reduce the size of instructional blocks or sections, 2) make the structure within each course more consistent, and 3) increase the quantity of off-line assignments. The original versions of the ALGEB and GENMA courses were revised by the Penn State Consortium staff on the basis of these recommendations. The current organization of the on-line programs is described in the section of this report entitled "Revised On-line Programs."

A second meeting of the teachers and the Penn State project staff was held in June 1970. The need to increase the quantity of off-line materials was again emphasized. The teachers also recommended that the chapter tests should be revised to make items in the test parallel with items in the instruction. Providing additional assignments and revising items in chapter tests were tasks assigned to the teachers during the summer of 1970.

Description of Content

As noted earlier, the content for both courses was selected with special regard for the inner-city target population; thus the reading difficulty for example, was kept to a certain minimal level, e.g., terseness was emphasized. Likewise, examples were drawn from content and from situations hopefully experienced by the students.

Determination of topics (see Appendix G for complete listing) to be included was accomplished by teachers from Philadelphia and Pittsburgh who spent approximately eighteen months on the Penn State campus. Working together with mathematics educators, the teachers identified objectives and planned units. As time pressures increased, however, specific behavioral objectives were omitted. This situation, in conjunction with a frequently-changing mathematics education staff, resulted in less consistency and articulation of topics as well as less emphasis on conscious decisions to employ identifiable teaching strategies than was anticipated. Thus the ultimate curricular outcome reflected the imprint of various authors and viewpoints.

The flowcharts (Appendix H) outline the sequence of moves within an instructional block. The term "instruction" as it is used here refers to that portion of the block in which new material is introduced. The pedagogical approach, whether expository or inductive, requires constant interaction of the pupil with the material in the computer. In fact, an expository passage (necessarily read on the CRT) must be extremely short to keep the attention of a population with reading difficulties. Thus, the teaching strategies used require continuous pupil interaction. Whether an author employs, for instance, a rule-example sequence or some other technique is up to him, but the decision should be made on the basis of an understanding of the interrelationships of strategy and objective

ALGEB

The core content of a standard algebra 1 course is well defined by current textbooks and curriculum guides. The scope and sequence of the materials developed under this project differ little from such a standard course. Figure 1 shows an abbreviated outline of the topics covered.

I. Numbers and Set Notation
II. Properties of Equality and Operations
III. Integers: Properties and Operations
IV. Operations with Rational and Real Numbers
V. Equations, Inequalities, and Problem Solving
VI. Linear Systems
VII. Polynomials
VIII. Factoring Polynomials

Fig. 1. An abbreviated outline of the ALGEB course.

In practice, the content selection was based on the curriculum guides of the Philadelphia and Pittsburgh school systems. These guides provided the minimum content listing. In addition, there was a mutual agreement among the author-teachers, school districts, and project staff, to sequence the material in such a way that it could be used with a standard textbook which all students would have. The text decided upon was: <u>ALGEBRA, A Modern Approach, Book 1</u>, by Peters and Schaaf.[4]

Modification of and exclusion of various algebraic topics within these constraints were determined by the participating teachers and mathematics education personnel on the project. Such alterations were based upon professional judgments by the staff that the material in question was, 1) peripheral to the basic algebraic skills required, and/or 2) too sophisticated for the target population at this point in the curriculum.

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[4]Max, P. and Schaff, W. L. <u>ALGEBRA, A Modern Approach, Book 1</u>. (2nd Ed.) D. Van Nostrand, Princeton, New Jersey, 1968.

Although the course, as it now exists, may not go as deeply into the material or as far as many college preparatory courses, it does provide the basic skills. It has the added advantage of being individualized with respect to the feedback which pupils receive. ALGEB off-line assignments came from the accepted textbook, but were done during class time as explained previously.

GENMA

The content of the GENMA course (see Figure 2) was determined solely by the participating teachers from Philadelphia and Pittsburgh and the Penn State Consortium staff at the initiation of the project. It was decided to include some topics traditionally considered to be part of algebra 1, such as equations, inequalities, negative integers, and graphing with coordinates, as well as arithmetic review.

I. Equations
II. Negative Integers
III. Division of Whole Numbers (Remedial only)
IV. Decimals
V. Fractions
VI. Ratio and Proportion
VII. Percent
VIII. Formulas
IX. Geometry
X. Measurement
XI. Graphing

Fig. 2. An abbreviated outline of the GENMA course.

Standard general mathematics topics, thought to be important for useful purposes, became part of the course: decimals and fractions, ratio and proportion, and measurement. The latter unit was approached through the content of geometry which was introduced first. The geometry was presented from a descriptive point of view with emphasis on fundamental topological notions in the early sections. Basic geometric figures were introduced and later employed to study notions of linear, square, and cubic measurement.

Graphing was approached first through the use of bar and picture graphs as practical aids in communication. This was expanded into coordinate graphing, ultimately of linear functions. As a motivational device, a computerized battleship game was employed in the learning of plotting points in a Cartesian plane.

Off-line work included, especially in the geometry and graphing units, activities other than rote drill. Manipulative and drawing tasks were included in regular assignments.

Utilization Patterns

Among other factors, optimal staff utilization is a function of room arrangement and the placement of terminals. The physical setup for the final year of the Consortium differed in the two schools and consequently the effectiveness of the planned staff utilization varied.

In Schenley High School (Pittsburgh) two separate rooms (see Figure 3) contained 15 terminals each. In addition, work tables with chairs were provided for students involved in off-line work assignments. Class size in each room was restricted to 30 pupils, only half of whom were on-line at a given time. Pupils were thus expected to be participating in on-line instruction during half of the scheduled class time. In general, a pupil devoted half of a class period to instruction and half to an off-line assignment, although this pattern was varied to suit individual differences resulting from such factors as learning rates and absenteeism. Pupils who moved very rapidly through the regular curriculum were assigned off-line enrichment work.

The physical arrangement in Lincoln High School presented a different picture (see Figure 4). Here all terminals were placed in a large, U-shaped open area. Off-line assignments were done at large tables in an area adjacent to the computer terminals. The teachers at Lincoln experimented with an alternate-day-on-line approach to terminal usage as opposed to half-period-on-half-

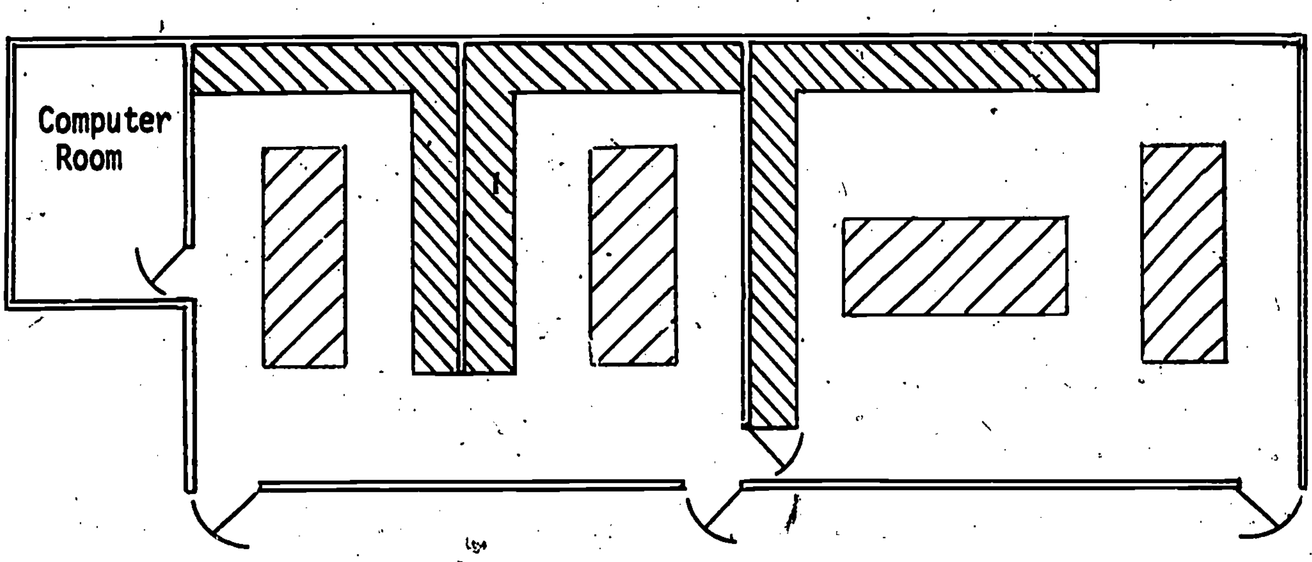

Fig. 3. Schenley room and terminal arrangement.

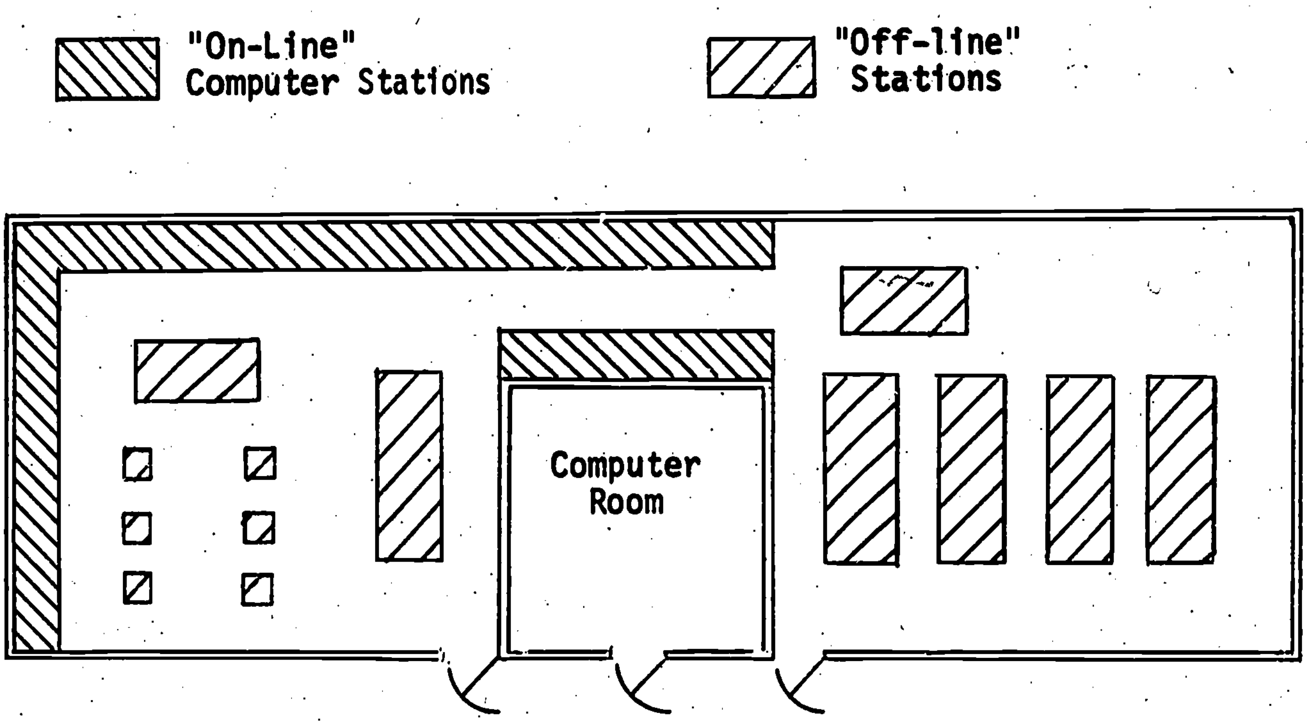

Fig. 4. Lincoln room and terminal arrangement.

period-off as done at Schenley. The material was not particularly designed for this time division and no conclusive evidence exists as to the better of the two time-use strategies.

After some initial experimentation during the early stages of the project, similar staff utilization plans were developed for the two schools. Because of computer disk storage constraints, only one of the two courses was available on-line at a given time. Thus the two classes scheduled together were necessarily in the same course. Two regular teachers, one for each class, and one course manager were present during a class period. The professional staff in each CAI setting was supplemented during most of the school year by two student teachers. The course managers were those teachers who originally came to Penn State to assist in the preparation of the course material. They were available to assist either of the other teachers or to help students directly. There was one course manager for ALGEB and one for GENMA in each school. They carried no direct responsibilities for particular classes but did have responsibility for 1) reporting program bugs and student and teacher reactions back to Penn State, 2) for inservice orientation of other teachers, and 3) for the overall operation of the classrooms.

Thus the presence of a tutorial computer system alters the role of the teacher from that of a principal source of cognitive information to that of the manager of an instructional environment. In addition to being competent in the subject matter area, the teacher must be able to identify the interests and abilities of each student, know the content of a variety of instructional materials, and be able to prescribe appropriate materials for each student.

CHAPTER III

SUMMATIVE EVALUATION

Marilyn Suydam, Edward Beardslee, and John Howell

Description of Evaluation Procedures

One of the difficult problems in evaluating a comprehensive educational program is the lack of control over a great many elements in the total program. Conducting summative evaluation, in which one curriculum and associated instructional techniques are compared in some formal way with a different curriculum/instruction model, involves both a comprehensive plan and a set of guidelines for use in making decisions when actual events make it necessary to deviate from a preliminary plan. In a real-life situation, many adaptations to emerging circumstances must be made; for instance, a teachers' strike in one district may necessitate a change in the testing schedule; a student disturbance and a high absentee rate may demand adjustments. These events represent limitations on the evaluation, in one sense; in another, since they are typical of the urban school environment today, the data should plausibly be expected to be confounded as a result of such incidents.

In the two curriculum/instruction models studies in this evaluative effort, the intent was to ascertain the relative effectiveness of each. The authors of this report have tried to avoid the use of the words "experimental" and "control" in describing the groups used in the evaluative study of achievement and attitude change. The "CAI group" was the one in which the computer was used to assist the instructional process, while the "cohort group" was the one in which the computer was not a component of the instructional process. The cohort classes in Pittsburgh were in a different school (Peabody) from the CAI classes (which were in Schenley). This strategy was necessary since all available general mathematics and algebra 1 classes in Schenley were included in the CAI group. The socio-economic level and the achievement level of students in Peabody is slightly higher than in Schenley, and this fact must be taken into consideration in interpreting the data. In Philadelphia, both CAI and cohort classes were drawn from Lincoln High School. The number of students in each group varies; Table 1 indicates the total number of students

Table 1

Total Number of Students in Each Curriculum Group

		General Mathematics		Algebra	
		CAI	Cohort	CAI	Cohort
Pittsburgh:	Schenley	140	x	254	x
	Peabody	x	88	x	97
Philadelphia:	Lincoln	220	77	221	104

involved in each group in each school. Since many students were absent on testing days, the number taking various tests and those who took all tests is an additional source of variation in standard laboratory research procedures.

A set of criterion measures was selected to study the effect of the varying modes of instruction on the achievement and attitudes of students in algebra 1 and general mathematics courses. Essentially, those were pre- and post-measures, usually administered by the teachers with the assistance of a member of the evaluation team.

The detailed outline in Figure 5 describes the specific measures used in the summative evaluation and indicates the dates of administration. In addition, formative evaluation of course content and of student achievement in various sections of the courses was continuing during the school year. Thus, regular, on-line chapter tests and mid-semester tests were administered to the CAI group, and the teacher's usual testing program was conducted in the cohort groups. Information derived from these tests was used in revision of the courses and for assigning marks to students.

Test or Scale	Course	Group	Administration Dates 1970-71 Pittsburgh	Philadelphia
Non-normed Achievement Test (Based on CAI curriculum objectives developed in Chapter II)	General Mathematics	CAI and Cohort	Sept. 11,30 June 9	Sept. 17,23 June 18
Non-normed Achievement Test (Based on CAI curriculum objectives developed in Chapter II)	Algebra	CAI and Cohort	Sept. 14,30 June 9	Sept. 18,23 June 18
Normed Achievement Test: Stanford Achievement Test (Form X, Pretest: Form W, Posttest)	General Mathematics	CAI and Cohort	Sept. 14,29 June 8	Sept. 18,22 June 17
Normed Achievement Test: Cooperative Mathematics Test (Form A, Pretest Form B, Posttest)	Algebra	CAI and Cohort	Sept. 11,29 June 8	Sept. 17,22 June 17
Attitude Toward Mathematics Scale	General Mathematics and Algebra	CAI and Cohort	Sept. 9,10,28 Feb. 2, Mar.1 June 4,7	Sept. 16,21 Jan.28,Feb.4 June 16
Attitude Toward Computer Assisted Instruction Scale	General Mathematics and Algebra	CAI	Oct. 23 March 1 June 4	Nov. 16, 17 Jan. 28 June 15
Attitude Toward Instructional Setting Scale	General Mathematics and Algebra	CAI and Cohort	June 7	June 16

Fig. 5. Outline of testing schedule.

Description of Instruments

Student Achievement

Both non-normed and normed tests were used to obtain measures of student achievement in each course. The term "non-normed" achievement test was coined to reflect the fact that there is no independent set of descriptive statistics concerning the sets of items used. These two tests, one for algebra and the other for general mathematics, were designed to reflect the fundamental objectives of the Consortium curricula as closely as possible. It was necessary in the operational settings of schools to restrict the amount of student time devoted to evaluation to an absolute minimum.

Non-normed achievement test for general mathematics. This off-line test, developed by Jansson and containing 33 items, was designed to measure mastery of 1) computation with the four operations with whole numbers and with positive rational numbers in fractional and decimal form, 2) ratio and percent, 3) linear equations, and 4) geometric concepts. Parallel forms were developed to serve as pre- and post-measures, containing identical items arranged in a different sequence. (See Appendix I for Form II of the test.)

Non-normed achievement test for algebra. This off-line test, developed by Beardslee and Jansson, contains 32 items. It includes both knowledge-level and understanding-level items of both computational and abstract-manipulation types, drawn from test-item pools from all chapters in the course. The posttest was an equivalent form, containing the items from the pretest ordered in a different sequence. (See Appendix J for Form II of the test.)

Normed achievement test for general mathematics. The Stanford Achievement Test, High School Basic Battery, Test 2: Numerical Competence, was selected to serve as a norm-referenced measure for general mathematics students. Form X was used as the pretest and Form W as the posttest. The test contained 45 items.

Normed achievement test for algebra. The Cooperative Mathematics Test, Algebra I, was selected to serve as a norm-referenced measure for algebra students. Forms A and B, each containing 40 items, were used as pre and posttests, respectively.

Student Attitudes

Attitudes toward the subject, the instructional medium, and the setting, were measured with specific instruments, and subjective, non-structured reactions were also requested.

Attitude Toward Mathematics Scale (Form B). This scale is one developed by Suydam and Trueblood. It has been used extensively with various groups of students; data from approximately 3,000 subjects indicate that the internal consistency reliability of the scale is approximately .95. The 26-item scale was administered at three intervals to both the CAI and the cohort groups. (See Appendix K for a copy of the scale.)

Attitude Toward Computer-Assisted Instruction Scale. This scale is a version, revised by Suydam, of one developed in the CAI Laboratory at Penn State. The original scale contained 50 items and had a reliability of approximately .82; the revised form consisted of 24 revised items, with reliability averaging .86. It was administered at three widely-spaced times only to the CAI group, since its intent (to ascertain reactions toward CAI) necessarily demanded experience on the computer terminals. (See Appendix L for a copy of the scale.)

Attitude Toward the Instructional Setting Scale (Form B). This scale, like the above two of a modified Likert type, was developed by Suydam and Beardslee to gauge student response to elements of the setting such as organization, individual help, the role of the teacher, and the relationship to fellow students. A pool of 250 items was written; from these 56 were selected on the basis of ratings by a set of ten judges. These 56 items were administered to three groups of students to secure item data, which were used in selecting the 30 items contained on the final version of the scale. The reliability of the instrument was found to be approximately .93. (See Appendix M for a copy of the scale.)

Reactions of students. Students in the CAI group were given the opportunity at various points in the course to submit, while on-line, their reactions to the course. While information derived from these comments was of use in the formative evaluation, many are also appropriate to the summative evaluation. A selection of these comments, drawn from computer print-outs, is therefore included. (See Appendix P.)

Teacher Attitudes and Behaviors

Reactions of teachers. The reactions of the teachers (involved in teaching with CAI in the project) form an important component of the evaluation, for upon them depended the day-to-day effect of the program upon the lives of students. From them other teachers learned of the project, and by them future users of the CAI courses will be guided. The teachers in each school were interviewed in early June in an informal discussion setting (see Appendix Q).

In lieu of a written statement of reactions from each teacher involved in the CAI Commonwealth Consortium Project, an informal meeting was held with those teachers (inservice and preservice) who were using CAI in each school district. They were asked to comment specifically on the four questions which follow, and to make any other observations they wished:

1) What have you learned as you worked with a CAI class?
2) What are the major problems or weaknesses?
3) What are the major achievements or strengths?
4) What would you do differently if the project were just beginning?

Their comments were noted as explicitly as possible: the statements are not always direct quotations of what any one person said, but reflect the individual or group intent.

Comments. While the reactions of the teachers are, in some cases specific to their individual situations, a few generalizations can be stated:

1) The GENMA course appears to have been developed more satisfactorily for CAI presentation than was the ALGEB course.

2) Systems (computer) problems need some attention. The use of the image projector is questioned.

3) More provision needs to be made for on-line practice.

4) More consideration needs to be given to the development and use of appropriate, integrated, coordinated off-line materials. (This was an area of major responsibility for teachers participating in the development of the courses.)

5) The facility with which CAI allows for individual rates of progress is viewed as both a bonus (when it allows for absenteeism, for instance) and a detriment (when students do not "cover" enough material).

6) New strategies must be developed for involving students in using the on-line program as an aid to learning (rather than merely "beating" the system).

7) The teacher's role is changed; individualizing instruction is more, not less, demanding than conventional mass education processes.

8) More care must be given to physical arrangements and planning for ease of management in the CAI classroom.

Classroom Observations

In a series of observations, the pattern of lessons in both CAI and cohort classes was analyzed using a Classroom Observation Form developed for this purpose. Information from these was used to develop a description of observable differences in the strategies being used in each type of classroom (see Appendix R).

It should be noted that the comments below are a composite of items observed on specific days, and are not intended as a generalized picture of what always occurs in each type of class. The Classroom Observation Form was used as a guide.

CAI classes. In all classes the pattern was similar: approximately half of the students were seated before the CAI terminals, while half were at tables in another part of the room. Those on CAI concentrated their attention, for the most part, on the material being presented to them via the computer. Occasionally they discussed a problem with the teacher or interacted with another student. The terminal response time was occasionally slow, so when there were delays on knowledge of results or proceeding to the next question of up to thirty seconds; pupils seemed annoyed, but most were patient. They were at various segments of the material (within a teacher-restricted range), and proceeded at their own pace.

The other students were working on worksheet-type paper-and-pencil materials, designed and assigned for practice, remediation, or enrichment. Concentration on the work was not total, but the general working climate was good. Teachers helped individuals with problems, and occasionally one student helped another.

Cohort classes. In all classes the entire group was involved in the same activity. In every case, this was teacher-directed, with pupils answering questions. Either a quiz or a homework assignment from the textbook served as the setting for the questions initially, but when new material was introduced, the textbook was referred to as a source of both guidance and questions. The example under discussion was written on the board and then solved; in one class, number lines were drawn to help students visualize the mathematics involved.

Questions generally called for brief responses, which were quickly accepted or rejected by the teachers. The last ten to fifteen minutes of the period was used as an individual work period by several of the teachers; they moved about the room, answered individual questions, and gave individual help during this time. Other than this there was evidence in only one class of individualizing instruction (in that class, the teacher actively sought to ask particular questions of particular students, as an aid to helping them understand the material).

In only one instance did a teacher overtly praise a student. The working climate covered a broad range: in one class, students vocalized dissatisfaction with the teacher (to each other, but not the teacher); in several classes, there was an undercurrent of student-to-student, irrelevant conversation; in two classes, the teachers had the full attention of almost the entire group.

Description of Analytical Procedures

A set of guiding questions for which answers were to be sought in the evaluation of the data was derived. As appropriate, the data were analyzed independently for the four distinct groups: general mathematics groups in Pittsburgh, algebra groups in Pittsburgh, general mathematics groups in Philadelphia, and algebra groups in Philadelphia. The set of questions is:

1. Is there a difference in achievement following instruction in CAI or non-CAI classes?
2. Is there a difference in attitudes following instruction in CAI or non-CAI classes?

3. Is CAI more effective for those of low or high ability (intelligence)?
4. Is CAI more effective for those with low or high initial achievement?
5. Are achievement and attitude related to previous achievement?
6. Are achievement and attitude related to attendance?
7. Are achievement and attitude related to number of years in school?
8. Are achievement and attitude related to "time-on-line" for the CAI groups?

The following types of data were collected:

1) achievement scores on normed and non-normed tests
2) attitude scores (toward mathematics, CAI, and setting)
3) intelligence test scores
4) previous achievement scores in mathematics and in reading (1969, 1970) on normed tests
5) attendance (absences in 1969, 1970, 1971)
6) number of years in school
7) time on-line

To analyze these data, the following statistical procedures and tests were used:

1) correlation: matrix and significance tests
2) factor analysis and rotation
3) analysis of variance with repeated measures

No attempt was made to compare data from the two districts, nor from the two courses. Thus, the data were treated as if derived from four separate sources: for general mathematics and for algebra, in Pittsburgh and in Philadelphia.

Results of Analyses of Data

Raw Score Data

Table 2 presents the high and low observed scores for both achievement tests, and Table 3 includes the extremes for number of absences and for amount of time on-line. It is evident that wide variability existed among the various groups. (The reliability coefficients for all tests and scales may be found in Tables N-1 and N-2 in Appendix N.

Tables 4 and 6 present the means of the raw scores for the two general mathematics groups (CAI and cohort) in Pittsburgh on the two achievement and the three attitude measures. The number of students in each instance (on Tables 4 through 11) is the number who took the test (not all students took all tests due to absences and school transfers.) The observations which may be made from these unabridged data are:

1) On both achievement measures, the CAI group made greater gains than did the cohort group.

2) The attitudes toward mathematics of the CAI group is slightly higher than that of the cohort group; scores of the CAI group increased more on the second administration, and decreased slightly on the third administration, while those of the cohort group showed a small but consistent increase.

3) Attitudes towards CAI became steadily less positive from fall to spring.

4) Attitudes toward the instructional setting were comparable for the two groups.

Tables 5 and 7 present the means of the raw scores for the two general mathematics groups in Philadelphia. It may be observed that:

1) On both achievement measures, the CAI group made greater gains than did the cohort group.

2) The attitudes toward mathematics of the CAI group increased on the second administration and then decreased, while those of the cohort group increased during the year, especially between the second and third administrations.

3) Attitudes toward CAI became steadily less positive from fall to spring.

4) Attitudes toward the instructional setting were much higher for the CAI group.

Table 2

Extremes of Achievement Scores for All Groups

	Pre-Instruction		Post-Instruction	
	non-normed	normed	non-normed	normed
Pittsburgh				
General Mathematics CAI Group	7-27[a]	3-40[b]	7-31[a]	1-38[b]
General Mathematics Cohort Group	8-33[a]	3-36[b]	4-29[a]	2-38[b]
Philadelphia				
General Mathematics CAI Group	7-25[a]	1-30[b]	7-30[a]	5-29[b]
General Mathematics Cohort Group	7-30[a]	6-31[b]	7-28[a]	6-32[b]
Pittsburgh				
Algebra CAI Group	4-18[c]	2-20[d]	5-26[c]	3-28[d]
Algebra Cohort Group	6-24[c]	5-24[d]	3-29[c]	5-29[d]
Philadelphia				
Algebra CAI Group	2-19[c]	1-21[d]	5-28[c]	7-28[d]
Algebra Cohort Group	4-24[c]	4-28[d]	4-24[c]	6-27[d]

[a]The non-normed achievement test for general mathematics contained 33 items.

[b]The normed achievement test for general mathematics contained 45 items.

[c]The non-normed achievement test for algebra contained 32 items.

[d]The normed achievement test for algebra contained 40 items.

Table 3.

Extremes of Number of Absences and Time-on-Line for All Groups

	Absences (In Days)			Time On-Line (Hours)
	1969[a]	1970	1971	
Pittsburgh				
General Mathematics CAI Group (N=140)	0-91	0-127	0-140	- 66.78[b]
General Mathematics Cohort Group (N=88)	0-55	1-63	0-62	None
Philadelphia				
General Mathematics CAI Group (N=220)	0-30	0-41	0-42	24.82 - 57.83
General Mathematics Cohort Group (N=77)	0-37	0-60	0-65	None
Pittsburgh				
Algebra CAI Group (N=254)	0-62	0-78	0-87	- 81.97[b]
Algebra Cohort Group (N=97)	1-35	0-34	0-53	None
Philadelphia				
Algebra CAI Group (N=221)	0-43	0-43	0-61	16.30 - 68.27
Algebra Cohort Group (N=104)	0-36	0-67	0-47	None

[a] Academic Year

[b] A meaningful minimum figure was not available for this group.

Table 4

Means on Achievement Tests Administered to General Mathematics Groups in Pittsburgh (Unabridged Data)

	Non-normed Achievement Test (33 items)					Normed Achievement Test (45 items)				
	Pretest		Posttest		Gain in	Pretest		Posttest		Gain in
Group	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$
CAI	131	14.33	118	18.96	4.63	131	13.99	73	16.95	2.96
Cohort	82	14.67	46	15.63	0.96	88	12.48	48	13.83	1.35

Table 5

Means on Achievement Tests Administered to General Mathematics Groups in Philadelphia (Unabridged Data)

	Non-normed Achievement Test (33 items)					Normed Achievement Test (45 items)				
	Pretest		Posttest		Gain in	Pretest		Posttest		Gain in
Group	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$
CAI	220	15.20	180	19.09	3.89	218	14.25	185	16.95	2.70
Cohort	69	15.10	64	17.19	2.09	68	13.63	72	15.96	2.33

Table 6

Means on Scales Administered to General Mathematics Groups in Pittsburgh (Unabridged Data)

	Attitude Toward Mathematics Scale							Attitude Toward CAI Scale							Attitude Toward Instructional Setting Scale	
	Fall		Winter		Spring		Gain in	Fall		Winter		Spring		Gain in		
Group	n	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$	n	$\overline{X}$
CAI	140	82.99	121	86.41	96	85.90	2.91	134	89.05	120	86.11	93	84.56	-4.49	96	99.07
Cohort	88	81.41	76	82.08	68	82.53	1.12				None				68	99.77

Table 7

Means on Scales Administered to General Mathematics Groups in Philadelphia (Unabridged Data)

	Attitude Toward Mathematics Scale							Attitude Toward CAI Scale							Attitude Toward Instructional Setting Scale	
	Fall		Winter		Spring		Gain in	Fall		Winter		Spring		Gain in		
Group	n	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$	n	$\overline{X}$
CAI	216	76.38	201	79.55	189	78.47	2.09	194	89.77	201	86.54	174	83.21	-6.56	189	99.92
Cohort	67	76.55	77	76.88	75	80.15	3.60				None				75	85.40

Tables 8 and 10 present the means of the raw scores of the two algebra groups in Pittsburgh. It may be observed that:

1) On the normed achievement measure, the cohort group made greater gains than the CAI group, while the CAI group made a greater gain on the non-normed measure. These are the anticipated results since each group did the best on the test whose objectives were closest to its own curriculum.

2) The attitudes toward mathematics of the CAI group increased and then decreased, while those of the cohort group steadily decreased; scores of the CAI group were more positive than those of the cohort group on both second and third administrations.

3) Attitudes towards CAI became steadily less positive from fall to spring.

4) Attitudes toward the instructional setting were higher for the CAI group.

Tables 9 and 11 present the means of the raw scores for the two algebra groups in Philadelphia. It may be observed that:

1) On both achievement measures, the CAI group made greater gains than did the cohort group.

2) The attitudes toward mathematics of the CAI group remained comparable between first and second administrations, and decreased quite sharply with the third administration, while for the cohort group there was a similarly sharp decrease between the first two administrations, followed by a slight increase.

3) Attitudes toward CAI became steadily less positive from fall to spring, with a large decrease evident between second and third administrations

4) Attitudes toward the instructional setting were higher for the cohort group.

Statistical Data

To ascertain whether the observed differences between means exceed chance findings and to secure answers to the set of questions presented previously, several hypotheses were tested. First, to determine which variables were

Table 8

Means of Tests Administered to Algebra Groups in Pittsburgh (Unabridged Data)

Group	Non-normed Achievement Test (32 items)					Normed Achievement Test (40 items)				
	Pretest		Posttest		Gain in	Pretest		Posttest		Gain in
	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$
CAI	247	9.30	152	13.95	4.65	249	8.64	180	11.62	2.98
Cohort	93	12.27	63	14.54	2.27	97	11.33	50	16.84	5.51

Table 9

Means on Tests Administered to Algebra Groups in Philadelphia (Unabridged Data)

Group	Non-normed Achievement Test (32 items)					Normed Achievement Test (40 items)				
	Pretest		Posttest		Gain in	Pretest		Posttest		Gain in
	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$
CAI	219	10.77	197	18.14	7.37	221	10.66	197	15.79	5.13
Cohort	104	9.95	72	13.06	3.11	100	10.35	69	13.75	3.40

Table 10

Means on Scales Administered to Algebra Groups in Pittsburgh (Unabridged Data)

Group	Attitude Toward Mathematics Scale							Attitude Toward CAI Scale							Attitude Toward Instructional Setting Scale	
	Fall		Winter		Spring		Gain in	Fall		Winter		Spring		Gain in		
	n	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$	n	$\overline{X}$
CAI	254	84.76	213	87.73	210	85.48	0.72	250	89.93	213	86.51	210	82.78	-7.15	173	100.22
Cohort	96	85.34	80	83.10	72	82.75	-2.29	None							72	93.33

Table 11

Means on Scales Administered to Algebra Groups in Philadelphia (Unabridged Data)

Group	Attitude Toward Mathematics Scale							Attitude Toward CAI Scale							Attitude Toward Instructional Setting Scale	
	Fall		Winter		Spring		Gain in	Fall		Winter		Spring		Gain in		
	n	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	n	$\overline{X}$	$\overline{X}$	n	$\overline{X}$
CAI	220	87.74	201	87.13	201	82.58	-5.16	212	92.13	201	90.06	167	74.76	-17.37	201	88.84
Cohort	102	84.53	71	78.32	73	79.21	-5.32	None							73	93.19

significantly correlated, all twenty-one variables were examined in a correlational matrix, for each of the locations, courses, and groups. Figure 2 contains a list of these variables. Each correlation coefficient was then tested for significance from zero and subjected to factor analysis (including rotation), to aid in the identification of the most plausible as well as those variables significantly different from zero. As was expected, the factor analysis ascertained that in several instances three or more of these variables were highly correlated, and clustered as a single factor. Therefore, one variable could be selected for use in further data analysis, with the expectation that the findings could be generalized to others in that cluster. Despite the clustering of achievement and attitude variables these were all retained, because they were essential in order to apply the repeated measures design. For those variables related to previous achievement and to number of absences, one of each set was selected. Thus, in subsequent data analyses, 15 variables (instead of 21) were utilized. (These retained variables are indicated in Figure 6 by asterisks.) The data for variables 12 through 20 were drawn from school records, while the amount of time-on-line was secured from records maintained by the instructional computer system.

For the statistical analyses to test the various hypotheses with sufficient precision, it was necessary to use data only for those students from whom all pertinent scores were available. Thus, for the first two questions, data from all students who had taken both pretest and posttest versions of both achievement tests were used; 657 students were involved. For the two questions related to attitude, data from all students who had been administered the two scales three times were used; this was true for only 470 students. The number varies, despite attempts to have all students complete all measures; the maximum number available was used for each of the analyses, however. In every instance, the plausible assumption remains that the removal of papers for those for whom data were incomplete does not bias the remaining sample for whom data are complete.

All null hypotheses were tested for significance at the .01 level.

1. Non-normed Achievement Test Score, Fall 1970 (pretest) *
2. Non-normed Achievement Test Score, Spring 1971 (posttest) *
3. Normed Achievement Test Score, Fall 1970 (pretest) *
4. Normed Achievement Test Score, Spring 1971 (posttest) *
5. Attitude Toward Mathematics Scale Score, Fall 1970 *
6. Attitude Toward Mathematics Scale Score, Winter 1971 *
7. Attitude Toward Mathematics Scale Score, Spring 1971 *
8. Attitude Toward Computer Assisted Instruction Scale Score, Fall 1970 *
9. Attitude Toward Computer Assisted Instruction Scale Score, Winter 1970 *
10. Attitude Toward Computer Assisted Instruction Scale Score, Spring 1970 *
11. Attitude Toward Instructional Setting Scale Score, Spring 1971
12. Number of Years in School *
13. Intelligence Score *
14. Mathematics Achievement Test Score, 1969
15. Mathematics Achievement Test Score, 1970 *
16. Reading Achievement Test Score, 1969
17. Reading Achievement Test Score, 1970
18. Number of Absences, 1968-69
19. Number of Absences, 1969-70
20. Number of Absences, 1970-71 *
21. Amount of Time On-line *

Fig. 6. Variables considered in correlational matrix, with clusters identified.

Non-normed Achievement Tests

The data from administration of the non-normed achievement tests were analyzed using Analysis of Variance (AOV)[2] as the analytical tool. The hypothesis being tested was the same in each of the four situations, for Pittsburgh general mathematics, Pittsburgh algebra, Philadelphia general mathematics, and Philadelphia algebra groups:

> There is no difference in achievement on the non-normed test (general mathematics and algebra considered separately) between groups following CAI or non-CAI instruction, as defined.

In the case of the non-normed achievement test, it seemed wise to attempt to adjust the posttest scores of the students in order to compensate for the fact that many of them did not complete the total program of instruction. When you allow students to pace themselves through content material, and when absentee rates vary from 0 to 75 percent of a 180-day school year there are inevitable fluctuations in the amount of course material actually attempted. Tables 12 and 13 show cumulatively the proportions of students in the four groups who completed each chapter of either the algebra or general mathematics course. If a youngster terminated more than half-way through a particular chapter, then he was counted as completing it. Posttest scores of every student were then adjusted to a base of either 33 items (general math) or a base of 32 items (algebra). Thus, as shown in Table 12, a student who finished Chapter 6 of general mathematics should have been able to answer 22 test questions correctly. Suppose he actually answered 20 correctly. His adjusted score became 20/22 or 91% of 33 or 30.

Table 15 shows a comparison of the unadjusted and adjusted posttest means. The adjustment created estimated increases in mastery level (percentages of test items correct) from 2 percent to 11 percent. The adjusted scores were used in the comparisons with the cohort group in Table 14.

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[2]The computer program used to analyze the data was ANOVR, Analysis of Variance with Repeated Measures, a general purpose analysis of variance routine which will handle completely crossed designs involving up to eight treatment factors

Table 12

Number and Percentage of Students who Completed Each Chapter in the Consortium Course in General Mathematics

Through Chapter	Number of Students Terminating in Chapter. Pittsburgh	Cumulative Total		Number of Students Terminating in Chapter. Philadelphia	Cumulative Total		Cumulative No. of Test Items Related to Each Chapter	
1	-	233	100%	-	222	100%	3	9%
2	8	233	100%	-	222	100%	5	15%
3	3	225	97%	-	222	100%	6	18%
4	80	222	95%	16	222	100%	13	39%
5	28	142	61%	46	206	93%	19	58%
6	27	114	49%	30	160	72%	22	67%
7	25	92	39%	56	129	58%	26	79%
8	13	67	29%	28	73	33%	28	85%
9	52	54	23%	42	45	20%	29	88%
10	2	2	1%	3	3	1%	31	94%
11							33	100%
Termination Date	6/4/71			6/16/71				

Table 13

Number and Percentage of Students who Completed Each Chapter in the Consortium Course in Algebra

Through Chapter	Number of Students Terminating in Chapter. Pittsburgh	Cumulative Total		Number of Students Terminating in Chapter. Philadelphia	Cumulative Total		Cumulative No. of Test Items Related to Each Chapter	
1	-	243	100%	-	220	100%	5	16%
2	22	243	100%	-	220	100%	7	22%
3	71	221	91%	-	220	100%	14	43%
4	110	150	62%	32	220	100%	17	53%
5	26	40	16%	123	188	85%	21	66%
6	11	14	6%	40	65	30%	23	72%
7	3	3	1%	25	25	11%	29	91%
8							30	94%
9							32	100%
Termination Date	6/4/71			6/16/71				

Table 14

Means for All Groups on Non-normed Achievement Tests (Abridged Data)

	CAI						Cohort					
	n	Pre	% Mastery	Adj. Post	% Mastery	Average Gain in Mastery %	n	Pre	% Mastery	Post	% Mastery	Average Gain in Mastery %
Pittsburgh General Math. (33 Items)	101	14.61	44	20.18	61	17	47	13.68	41	15.23	46	5
Philadelphia General Math. (33 Items)	156	14.89	45	20.17	61	16	63	14.63	44	14.83	45	1
Pittsburgh Algebra (32 Items)	135	9.42	29	15.82	49	20	64	12.58	39	14.23	44	5
Philadelphia Algebra (32 Items)	183	10.69	33	20.65	65	32	75	9.49	30	12.44	39	9

Table 15

Comparison of Adjusted and Unadjusted Mean Posttest Scores and Mastery Levels for CAI Groups on Non-normed Achievement Tests

	n	Unadjusted Posttest Mean	Mastery Level	Adjusted Posttest Mean	Mastery Level
Pittsburgh General Math. (33 Items)	101	19.57	59%	20.18	61%
Philadelphia General Math. (33 Items)	156	17.45	53%	20.17	61%
Pittsburgh Algebra (32 Items)	135	13.86	43%	15.82	49%
Philadelphia Algebra (32 Items)	183	17.43	54%	20.65	65%

Table N-3 (Appendix N) presents the AOV summary table for Pittsburgh general mathematics groups. The increase in achievement scores between pretest and posttest (unadjusted) was significantly greater for the CAI group than for the cohort group. This interaction effect for adjusted posttest means is illustrated on the graph in Figure 7.

Table N-4 (Appendix N) presents the AOV summary table for Philadelphia general mathematics groups. The significantly greater increase in achievement scores of the CAI group is illustrated in Figure 8.

Table N-5 (Appendix N) presents the AOV summary table for Pittsburgh algebra groups (unadjusted data). Again, the increase in achievement scores was significantly greater for the CAI group than for cohort groups, as illustrated in Figure 9.

On Table N-6 (Appendix N) is the AOV summary table for Philadelphia algebra groups (unadjusted data). Once again, the increase in achievement scores is significantly greater for the CAI group than for the cohort group, as illustrated in Figure 10.

Summary

On the non-normed achievement test, the CAI groups in both school districts and in both mathematics courses made significantly greater increases in achievement scores between pretest and posttest than did the cohort groups. The replication of this result is indicative of the efficacy of the non-normed test for each course in ascertaining whether or not the CAI programs were effective.

Normed Achievement Tests

The data from administration of the normed achievement tests was also analyzed using Analysis of Variance (AOV) as the analytical tool. The hypothesis being tested was the same in each of the four situations:

> There is no difference in achievement on the normed test (general mathematics and algebra considered separately) between groups following CAI or non-CAI instruction.

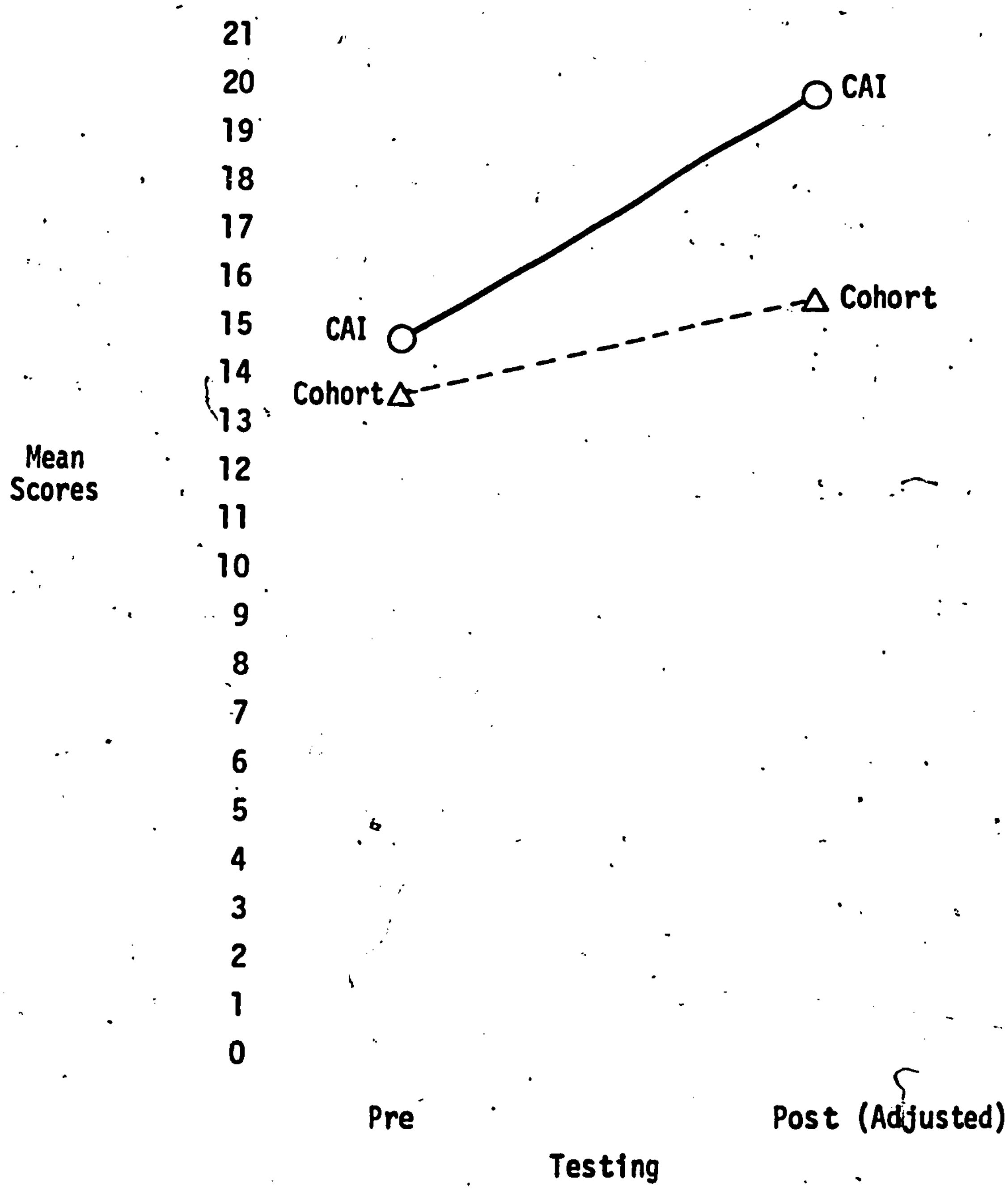

Fig. 7. Mean scores on non-normed achievement test for Pittsburgh general mathematics groups. (Abridged Data)

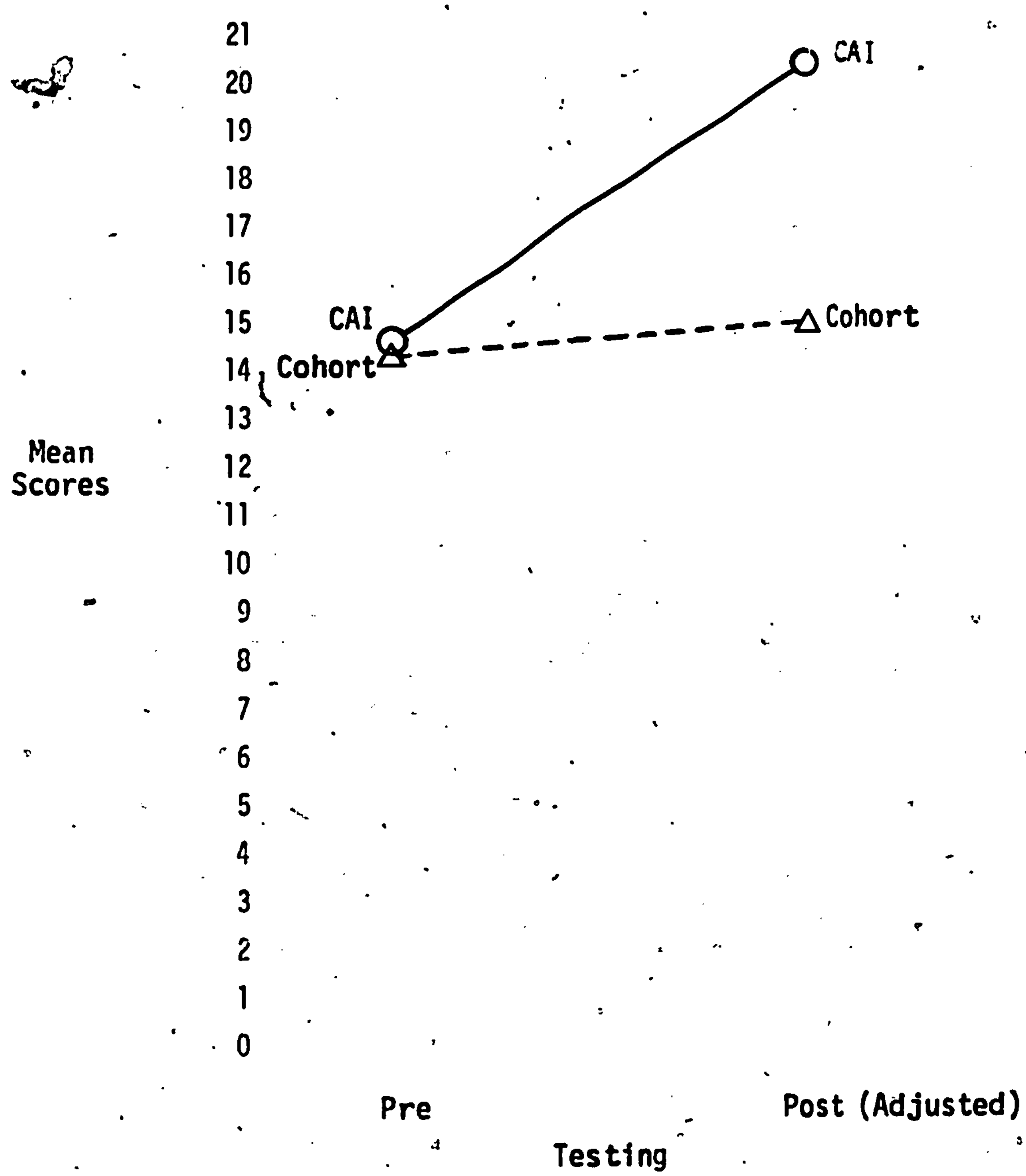

Fig. 8. Mean scores on non-normed achievement test for Philadelphia general mathematics groups.

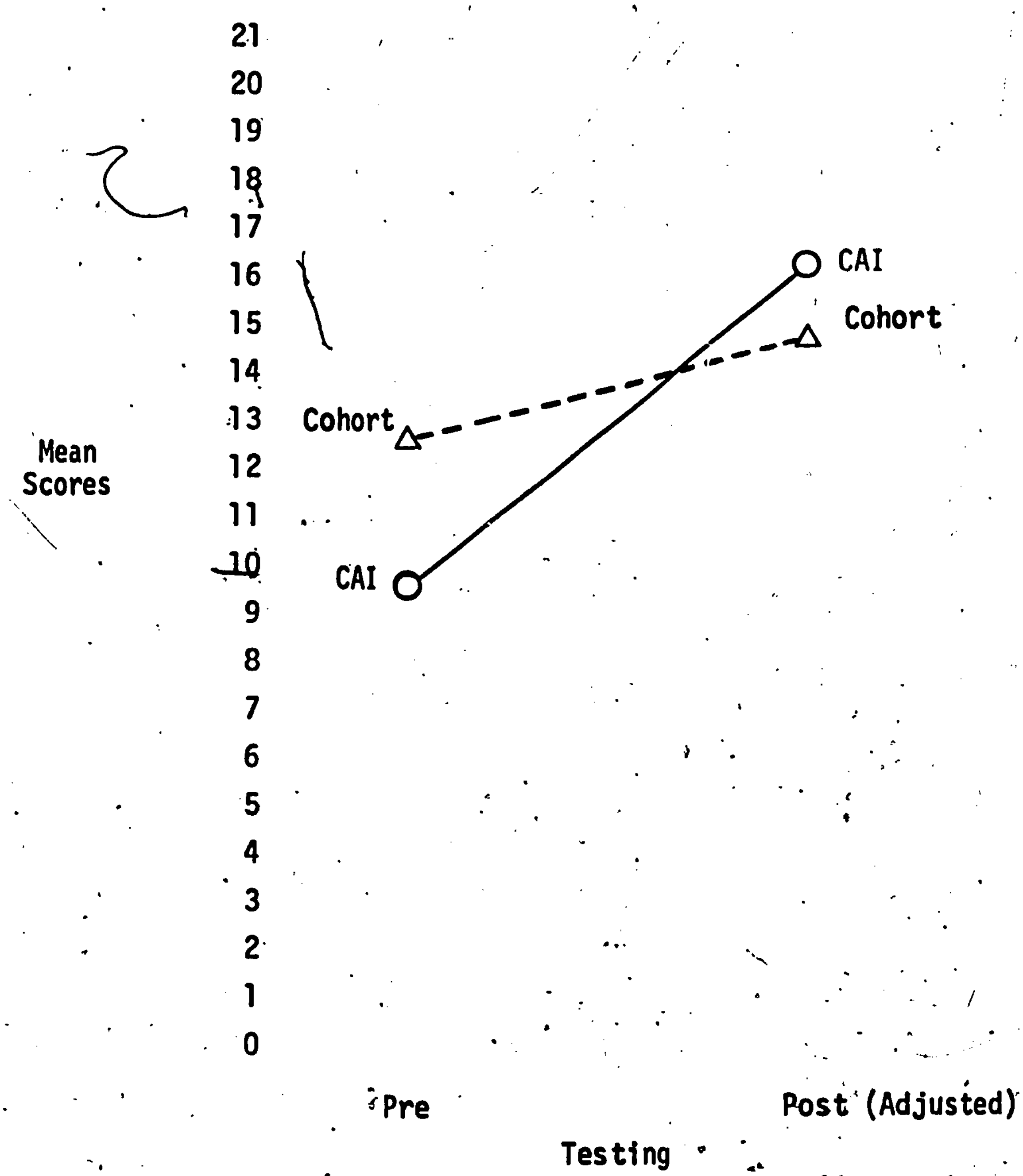

Fig. 9. Mean scores on non-normed achievement test for Pittsburgh algebra groups.

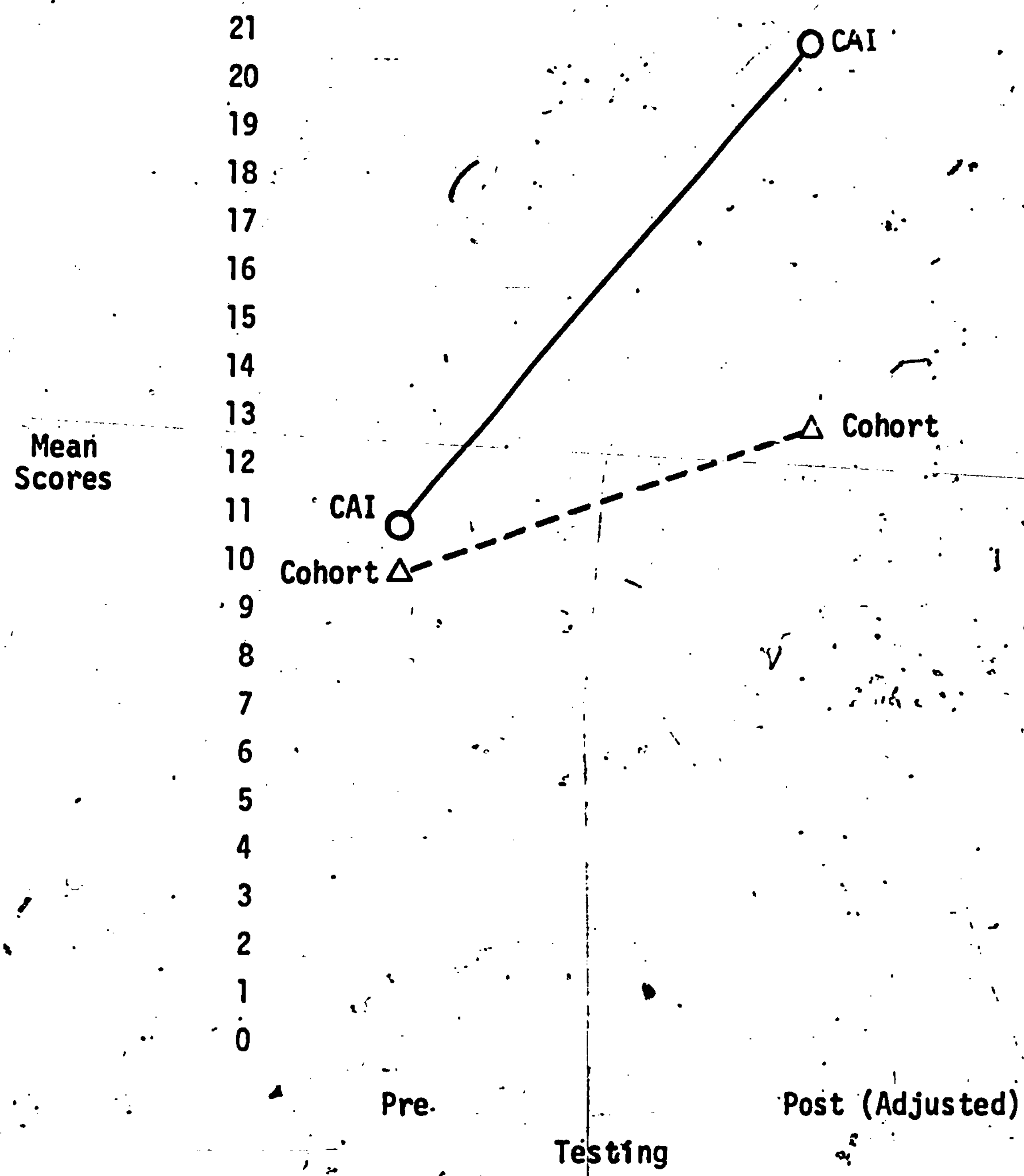

Fig. 10. Mean scores on non-normed achievement test for Philadelphia algebra groups.

The means for all groups are presented in Table 16. Tables N-7, N-8, N-9, and N-10 (Appendix N) present the AOV summary tables for each of the four groups.

In each situation, there was no significant interaction effect between type of instruction and pre-post gain. The null hypothesis stated above was not rejected. There was a significant testing main effect in all cases, indicating an increase in achievement scores for all groups; the four groups all showed improvement from pretest to posttest.

Summary

The fact that students in both the CAI and cohort groups achieved a mastery level of 30-40 percent on the normed achievement tests casts considerable doubt on the adequacy of these tests for measuring student changes over two semesters. The obtained differences were not significant for CAI and cohort groups.

Attitude Toward Mathematics

The data from three administrations of the Attitude Toward Mathematics scale were also subjected to the Analysis of Variance (AOV) procedure. The hypothesis being tested, for each of the four situations, was:

> There is no difference in attitude toward mathematics between groups following CAI or non-CAI instruction.

On Table 17 are the means for all four groups.

The AOV summary tables are presented on Tables N-11 through N-14 (Appendix N). The results for the Pittsburgh general mathematics group indicates a significantly greater increase in attitude toward mathematics for the cohort group. Figure 11 illustrates this finding.

For the Philadelphia general mathematics group, there was a significantly greater increase in attitude toward mathematics for the CAI group, as illustrated in Figure 12.

Table 16

Means for All Groups on Normed Achievement Tests (Abridged Data)

	CAI						Cohort					
	n	Pre	% Mastery	Post	% Mastery	Average Gain in Mastery %	n	Pre	% Mastery	Post	% Mastery	Average Gain in Mastery %
Pittsburgh General Math. (45 Items)	107	14.32	32	17.36	39	7	47	11.72	26	13.64	30	4
Philadelphia General Math. (45 Items)	176	14.57	32	15.82	35	3	63	12.59	28	14.63	33	5
Pittsburgh Algebra (40 Items)	180	8.56	21	11.62	29	8	64	11.64	29	15.25	38	9
Philadelphia Algebra (40 Items)	194	10.70	27	14.82	37	10	75	9.49	24	12.51	31	7

Table 17

Raw Score Means for All Groups for Three Administrations of Attitude Toward Mathematics Scale

	CAI				Cohort			
	n	Fall	Winter	Spring	n	Fall	Winter	Spring
Pittsburgh General Math.	61	82.57	87.41	97.59	42	81.40	79.76	101.26
Philadelphia General Math.	111	74.77	78.55	99.97	40	78.65	78.33	80.73
Pittsburgh Algebra	143	85.73	88.54	98.28	52	86.42	85.50	92.75
Philadelphia Algebra	155	89.66	88.52	89.52	51	86.96	81.24	95.10

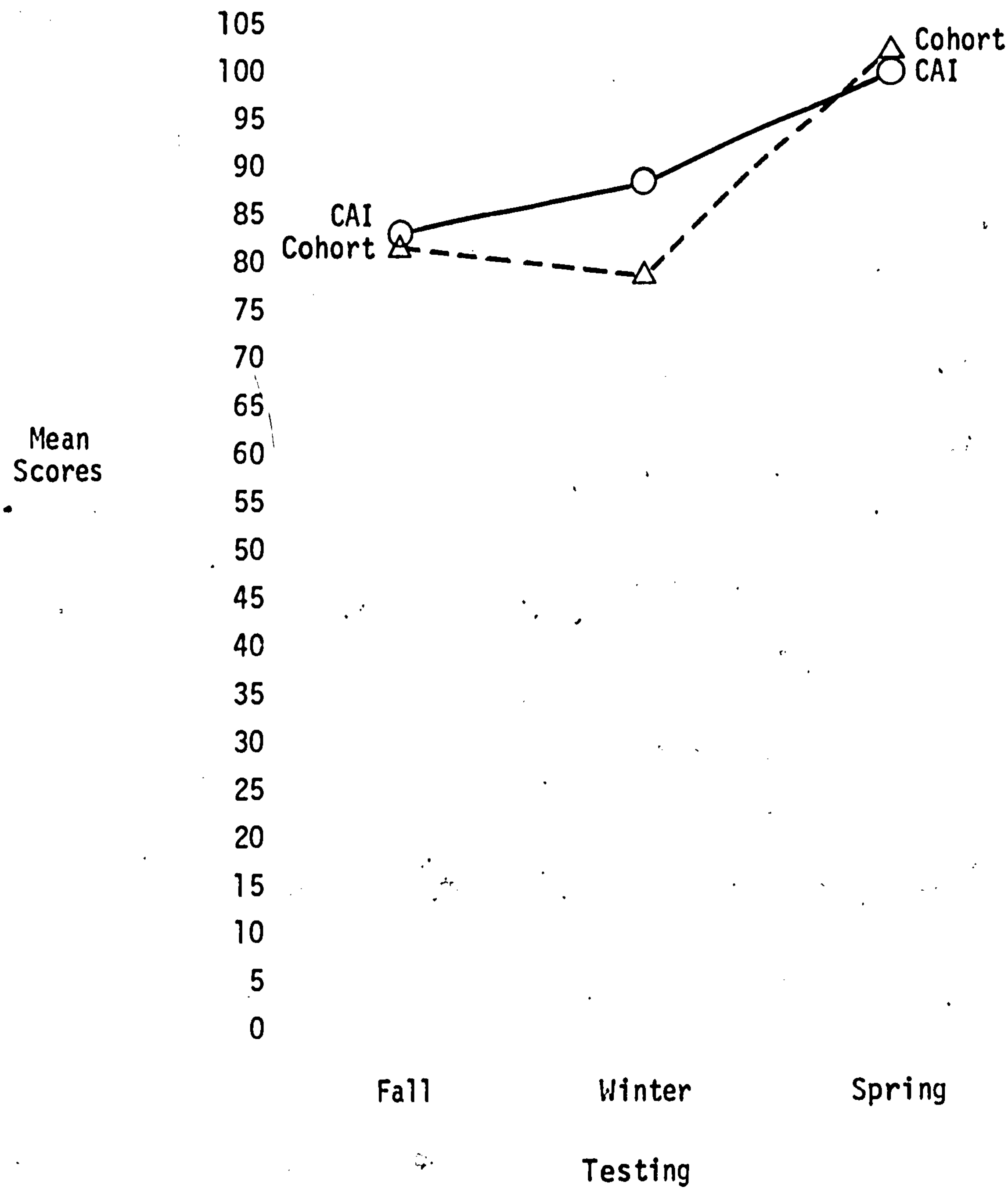

Fig. 11. Mean scores from Attitude Toward Mathematics scale for Pittsburgh general mathematics groups.

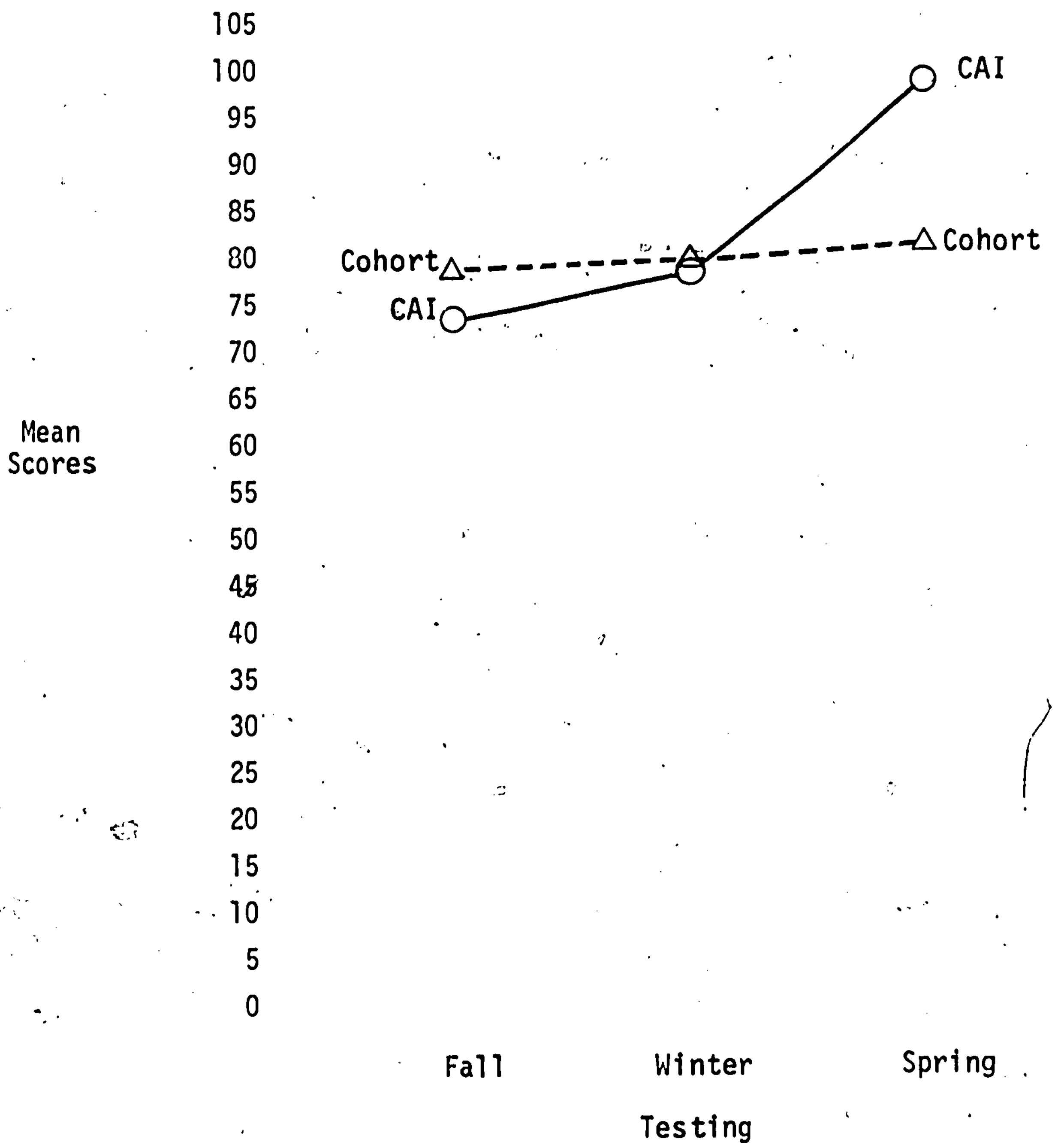

Fig.12. Mean scores from Attitude Toward Mathematics scale for Philadelphia general mathematics groups.

For the Pittsburgh algebra groups, there was a significant difference only for the pre-post gain; that is, both CAI and cohort groups had a significantly more positive attitude toward mathematics in spring than they had in the fall or mid-year. However, the observed difference between groups, while not significant, favored the CAI group.

The results for the Philadelphia algebra group indicate a significantly greater increase in attitude toward mathematics for the cohort group (see Figure 13).

Summary

No consistent pattern in attitude toward mathematics was found across the four situations.

Attitude Toward Computer Assisted Instruction

The data from three administrations of the Attitude Toward Computer Assisted Instruction scale to the CAI groups was also tested with the Analysis of Variance (AOV) procedure. The hypothesis being tested in each of the four situations was:

> There is no difference in students' attitude toward computer assisted instruction when measured in fall, winter, and spring periods of the school year.

Table 18 presents the means for the four CAI groups.

The AOV tables for each situation are presented on Tables N-16 through N-18 (Appendix N). A significant decrease in attitude toward CAI was found for all four groups.

Mode/Ability Effects

The question, "Is CAI more effective for those of low or high ability?" has frequently been asked, as well as the related question about its efficacy for those of low or high achievement. Since ability and previous achievement were found to be highly correlated, it seemed prudent to test the data for only one variable. Ability, defined by an intelligence test score, was

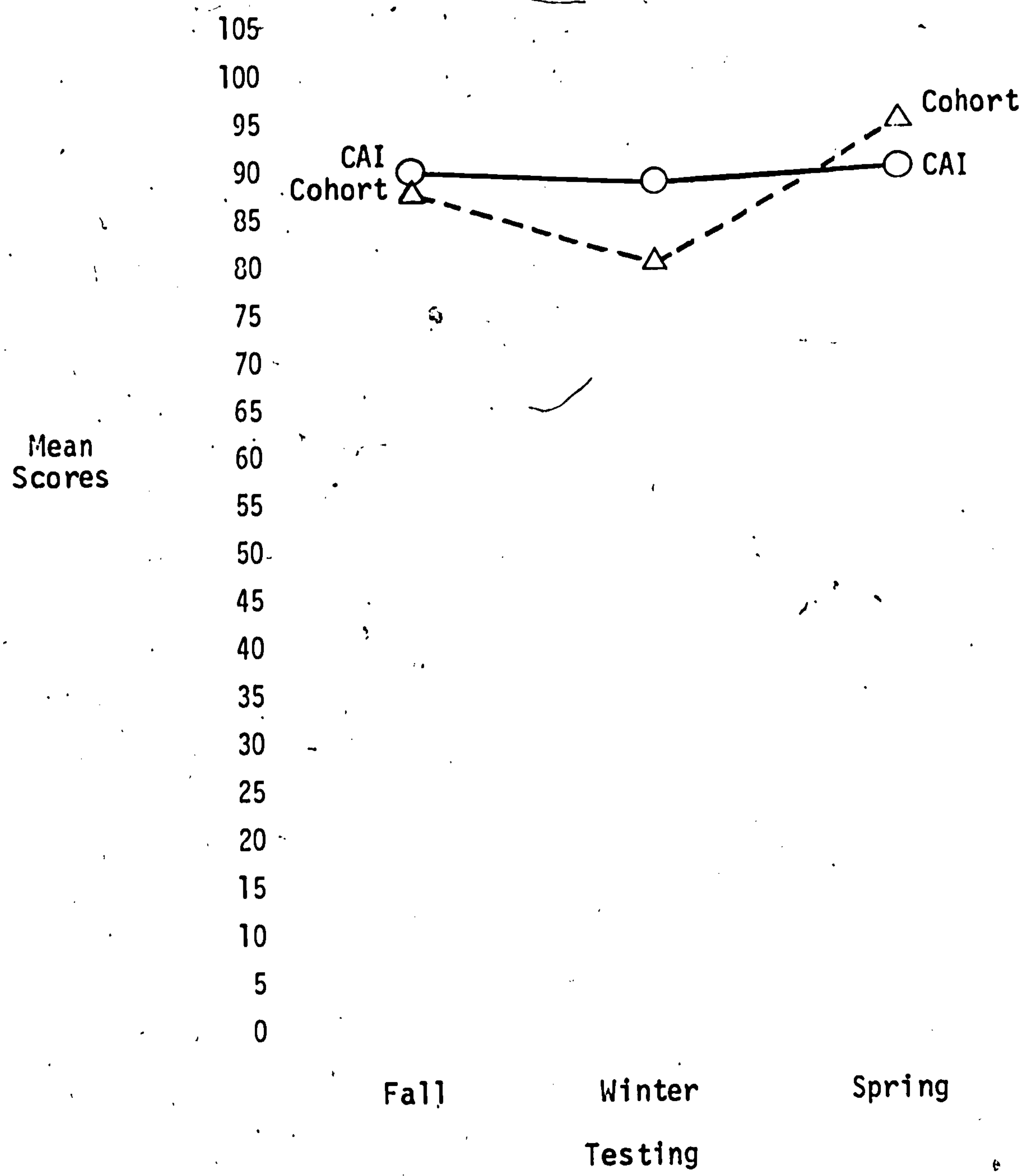

Fig.13. Mean scores from Attitude Toward Mathematics scale for Philadelphia algebra groups.

Table 18

Means for CAI Groups for Three Administrations of Attitude Toward Computer Assisted Instruction Scale

	n	Fall	Winter	Spring
Pittsburgh General Math.	61	89.49	86.20	75.84
Philadelphia General Math.	111	89.46	87.32	82.87
Pittsburgh Algebra	143	90.20	86.18	81.50
Philadelphia Algebra	155	92.45	89.62	58.88

selected. The achievement variable was defined by the non-normed test score, because this score and the intelligence test score were not highly correlated and it was necessary to have independent measures.

High and low ability were defined, in relation to each situation, as the highest and lowest 27 percent of the scores attained on the intelligence test. Therefore, the extremes and number of scores is different for each group, as can be noted on Table 19. (The mean IQ score for each group was also variable.)

The means for the achievement of these groups are given on Table 20.

The AOV summary tables are presented for each of the four situations on Tables N-19 through N-22 (Appendix N). It should be noted by the reader that the analysis of variance is not strictly applicable to the problem where the independent variable or dimension is continuous and when the researcher defines his groups (in this case high and low) in terms of a characteristic of the sample. He is making a split of convenience which fluctuates with sample values. Such analyses cannot be replicated on independent samples hence there is a considerable cloud over the interpretation of the data.

For the Pittsburgh general mathematics group and for the Philadelphia algebra group, scores increased for all students; there was no significant interaction between ability level and achievement.

Table 19

Extremes and Number of Students in High and Low Ability Groups

	Limits High	n	Limits Low	n	$\bar{X}$ Score For Total Group	Test Used
Pittsburgh General Math.	101 - 120	12	62 - 86	12	92.36	Otis
Philadelphia General Math.	110 - 125	18	85 - 95	14	103.69	Phila. Mental Abilities
Pittsburgh Algebra	101 - 118	34	63 - 86	19	95.22	Otis
Philadelphia Algebra	125 - 130	28	80 -108	21	113.15	Phila. Mental Abilities

Table 20

Means for Achievement of High and Low Ability Groups in CAI Instruction

	High		Low	
	Pre	Post	Pre	Post
Pittsburgh General Mathematics	16.75	23.00	12.92	17.17
Philadelphia General Mathematics	17.44	21.61	12.36	15.21
Pittsburgh Algebra	9.62	15.82	9.05	11.52
Philadelphia Algebra	10.29	16.14	12.05	18.71

For the Pittsburgh algebra group, a significant interaction was found: scores of those students in the high ability group improved significantly more than those of students in the low ability group.

Results for the Philadelphia general mathematics group indicated no significant differences between the groups.

Summary

In only one situation (algebra classes in Pittsburgh) did CAI appear to be more effective for students of high ability than for those of low ability.

Correlational Results

The answers to four of the questions listed below can be obtained by referring directly to the correlation data on Tables N-23 through N-26 in Appendix N.

1. Are current achievement and attitude related to previous achievement?

   For all four CAI groups and for the Pittsburgh cohort algebra group, significant correlations were found between current achievement and previous achievement (as measured by 1970 mathematics normed test scores). Three of the four correlations for CAI groups on the mathematics attitude scale were significant (only that for the Philadelphia general mathematics group was not). Thus, achievement and mathematics attitude appear to be correlated more for CAI groups than for cohort groups.

2. Are achievement and attitude related to attendance?

   Only with one group--Philadelphia CAI algebra group--were any significant correlations with attendance (as defined by the number of absences in the present 1970-71 school year) found. These were on the non-normed achievement test and the mathematics attitude scale, and in both cases, the fewer days absent, the higher the scores. All of the remaining data, however, indicated an inability to refute the null hypothesis.

3. Are achievement and attitude related to number of years in school?

   No significant correlations were found for any group; thus, the hypothesis that achievement and attitude appear unrelated to number of years in school could not be refuted.

4. Are achievement and attitude related to amount of time-on-line for the CAI group?

   Examination of the data on the range of on-line time (see Table 3) indicates that there was an error in the records kept by the computer in Pittsburgh. The correlation coefficients are (by inspection) slightly higher for Pittsburgh students than for Philadelphia students, where the computer was (apparently) maintaining a more accurate record of time. However, they are low and non-significant, and the following conclusion appears justified: No significant correlations were found for any group; thus, the hypothesis that achievement and attitude are unrelated to the amount of time the student spends on-line could not be refuted.

Comments Related to Data Analysis

The summarized results of the statistical analyses indicate:

1) On the non-normed achievement test, the CAI groups made significantly greater increases in achievement than did the cohort groups. The reader is reminded that the non-normed achievement test was based on the Consortium curriculum.

2) Three of the four CAI groups attained a mean projected mastery level of 60 percent on the non-normed achievement test.

3) On the normed achievement test, no significant differences between CAI and cohort groups were found.

4) No consistent pattern in attitude toward mathematics was found.

5) A significant decrease in attitude toward CAI from fall to spring was found for CAI groups.

6) Generally, CAI did not appear more effective for students of high ability than for those of low ability.

7) Achievement and mathematics attitude appear to be correlated more for CAI groups than for cohort groups.

8) Achievement and attitude were not significantly related to attendance or to number of years in school.

9) Achievement and attitude were not significantly related to the amount of time students in the CAI groups spend on-line.

The two types of achievement tests were highly correlated, yet the non-normed tests apparently provided a more precise measure of the achievement of those students having computer-assisted instruction than did the normed test. This finding could be anticipated, since the non-normed test was written to test the objectives of the CAI course.

The significant decrease in attitude toward CAI was not anticipated, however. Perhaps it is a function of increasing student dissatisfaction with the slow response time of the computer, or to the restrictions or the pressure which is imposed by the computer. It is interesting to note that their subjective comments do not, in general, agree with the results of this more objective measure.

That no achievement/ability interaction was found may be taken as an indication that CAI programs can be written so that they are effective for students at varying levels. Thus, individual differences have been provided for to some extent.

It was somewhat surprising that no correlation between amount of time on-line and achievement was found. This may be another sign of the individualized pattern of instruction; it could be interpreted as an indication that all students can achieve if they are given an appropriate length of time.

The results indicate that students can achieve at least as well with the use of CAI as from conventional instruction alone. Attitude toward mathematics need not suffer, though attitude toward CAI did become increasingly negative.

CHAPTER IV

CAI COST ANALYSIS

Keith A. Hall

The magnitude and complexity of this project requires that a summary analysis be made to assist other educational institutions in considering the adoption and use of the programs and products produced by the Consortium staff A simple reporting of the resources required to operate this project will not suffice because many of those resources were directed toward the development, trial, and revision of curriculum, the development and revision of utilization patterns and techniques, and the cost of a large-scale evaluation of the curriculum. This report attempts to generalize from the experience derived from an in-school CAI program. It further includes the experience derived from an inservice teacher education project so that pondering institutions may set forth a plan of implementation for a CAI program with maximum educational benefits through high-volume use of the instructional computer system for on-line tutorial instruction and for educational data processing.

In order to make adequate judgments about the costs of providing education through computer-assisted instruction, certain assumptions must be made regarding the characteristics of the computer system, the available curriculum, the useful life of the system, the use schedule and staff requirements, and the financial plans for supporting the program. These factors may all vary depending upon the specific needs and requirements of a school district, but certain assumptions have been made, based upon experience with in-school CAI and inservice teacher education, from which realistic cost estimates can be made.

Instructional Computer System

The IBM 1500 instructional system on which these cost projections were made consists of thirty instructional stations with cathode-ray tube display, light pen, typewriter keyboard, audio device, and image projector. The computer room equipment is comprised of an 1131 central processing unit, 1132 printer, 1442 card reader and punch, 1133 multiplexor control unit, two 2310 disk storage drives, 1502 station control, two 1518 typewriters, and two 2415 tape drives.

The central processor is an IBM 1130 computer with 32,768 16-bit words of core storage. In addition to the usual peripheral equipment, the central processor depends upon five IBM 2310 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 microseconds and read/write time for disk storage is 27.8 microseconds per word.

Each IBM 1500 student station consists of three 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 16 horizontal rows and 40 vertical columns for a total of 640 display positions. Information sufficient to fill the screen is available from a dedicated disk in the station control. A light pen device enables a 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 and have them displayed at any author-desired point on the CRT screen. Also, by way of the CRT screen, the student receives rapid feedback in the form of an evaluative message. Four dictionaries of 128 characters each, of the author's own design, are capable of being used simultaneously. An image projector loaded with a 16mm microfilm is capable of holding 1024 images on a single roll and of accessing 40 images per second under program control. An audio play/record device based on a four channel 1/4-inch tape is an integral part of the system. The two electric typewriters on the system are separate devices which enable the proctors to receive a paper copy of information about students' progress in the course. The configuration of the CAI system is shown in Appendix A.

Table 21 presents the costs for purchasing and maintaining the computer system described above. These costs have been divided into three major headings:

Table 21

IBM 1500 Instructional System
Purchase and Maintenance Costs, 7/1/71[a]

Computer System	Unit Purchase	Total Purchase	Unit Monthly Maintenance	Monthly Maintenance	Annual Maintenance
Common Components: Dedicated and Time Shared Modes					
2 - 2310 Disk Storage Units	$ 37,980	$ 75,960	$146.00	$ 292.00	$ 3,504
1 - 2415 Magnetic Tape Unit	34,580	34,580	100.00	100.00	1,200
1 - 1131 Central Processor	107,955	107,955	170.50	170.50	2,046
1 - 1133 Multiplex Control	28,655	28,655	37.25	37.25	447
Subtotal: Dedicated and Time Sharing Mode	$209,170	$247,150	$453.75	$ 599.75	$ 7,197
Components for Dedicated Mode Only					
1 - 1132 Printer	$ 11,010	$ 11,010	$ 25.00	$ 25.00	$ 300
1 - 1442 Card Read/Punch	14,140	14,140	51.00	51.00	612
Subtotal: Dedicated Components	$ 25,150	$ 25,150	$ 76.00	$ 76.00	$ 912
Components for Time Shared Mode Only					
1 - 1502 Station Control	$ 75,155	$ 75,155	$ 65.00	$ 65.00	$ 780
30 - 1510 Inst. Display w/Light Pen	2,755	82,650	13.50	405.00	4,860
30 - 1512 Image Projectors	3,455	103,650	14.25	427.50	5,130
2 - 1518 Typewriters	3,035	6,070	35.00	70.00	840
8 - Station Connectors	480	3,840			
Cables	10,000	10,000			
Subtotal: Time Shared Components Without Audio	$ 94,880	$281,365	$127.75	$ 967.50	$11,610
Subtotal: Time Shared Components With Audio	$ 99,140	$409,165	$182.75	$2,617.50	$31,410
GRAND TOTAL: Without Audio		$553,665	$657.50	$1,643.25	$19,719
GRAND TOTAL: With Audio		$681,465	$712.50	$3,293.25	$39,519

[a]The dollar values listed in this report are unofficial and subject to change by the vendor.

1) common components for dedicated and time shared modes;
2) components for dedicated mode only; and
3) components for time shared mode only.

These cost figures are used throughout the remainder of this report for determining amortization costs and hourly rates for the instructional system.

Curriculum Materials

The major focus of this project was the development, revision, and evaluation of two high school level mathematics courses--general mathematics and algebra. For a school system with at least 500 pupils in the ninth grade where these courses are normally taken, these courses and pupils would fully utilize the system during the regular school hours. Schools with less than 500 students at that grade level might want to investigate other curriculum materials available for the IBM 1500 system and which are indexed and annotated in the Index to Computer Assisted Instruction written by Lekan, Helen.[1]

The general mathematics course has been found to be of use in the adult education program at the Schenley High School in Pittsburgh. Presumably after adult basic education students had finished the general mathematics program, the algebra program could become a second course in a mathematics sequence. Adult education in the form of inservice teacher education has been shown to be successful and, in fact, two courses are now available. One Mathematics for Elementary Teachers, is composed of approximately 80% content of mathematics and 20% methods of teaching mathematics. This course has been administered successfully to over 500 preservice and inservice teachers. The range in student time required is 44 hours (12 hours to 56 hours), with the mean completion time being about 20 student station hours. A second course for teacher education, Early Identification of Handicapped Children, is designed to give preschool and primary teachers of seemingly typical children the knowledges and skills necessary to identify children with handicapping conditions who otherwise might be educationally retarded by the age of nine or ten. This course

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[1] Lekan, H. Index to Computer Assisted Instruction. Sterling Institute, 1969.

has been offered to approximately 700 teachers in rural Pennsylvania and is continuing to be offered at the rate of about 1,000 teachers per year by means of a mobile CAI facility. The range in student time required is 46 hours (14 hours to 60 hours) with the mean completion time being about 25 student-station hours. Proposals to develop CAI courses in science, reading, and further course development in special education have been submitted to funding agencies and are presently under consideration. These courses would all be compatible with the computer system described in this report.

Useful Life of the System

The useful life of the system is assumed to be 15 years. This estimate is based upon the following factors.

1. The manufacturer of the system does not provide an estimated life expectancy of the system or the components but has stated that the corporation will maintain the system as new indefinitely as long as the owner has a maintenance agreement with the corporation.

2. Once the system is installed and the curriculum is available it can be used indefinitely much as a school district continues to use school buildings even though they may build newer and more modern facilities.

Instructional Computer System Use Schedule and Staff Requirements

Because the system is specifically designed for instructional uses and a large proportion of the components are designed and used only for instructional purposes, computer-assisted instruction applications are given preference over a dedicated use of the system. The combined use of a CAI system for secondary school education and adult education could result in very economical tutorial instruction. Table 22 presents a proposed system schedule for secondary school and adult education use. For secondary school education, the system would be in use from 8:30 a.m. through 3:30 p.m. during the school year (180 days) and from 8:00 a.m. until 12:00 noon during a thirty-day summer session. When an adequate number of students are available who need to use the student stations, experience has shown that a utilization level of 90% can be expected. This schedule of public school use and a utilization level of 90% would provide

Table 22

Computer-Assisted Instruction Use Schedule (Time-Shared Mode) and Staff Requirements

Schedule	Days	Hrs./Day	Total Clock Hours	Percent Util.	Student Station Hours	Staff on Duty: Manager Qty.	Manager Hours	Proctor Qty.	Proctor Hours	Operator Qty.	Operator Hours
Secondary School Education											
School Year (36 weeks) 8:30 - 3:30 p.m.	180	7	1,260	90	34,020	1	1,260	2	2,520		
Summer School (6 weeks) 8:00 - 12:00 noon	30	4	120	90	3,240	1	120	2	240		
Subtotal - Secondary School Education	210		1,380		37,260		1,380		2,760		
Adult Education											
School Year (36 weeks) 4:00 - 10:00 p.m. (week days)	180	6	1,080	90	29,160			2	2,160	1	1,080
8:00 - 4:00 p.m. (Saturdays)	36	8	288	90	7,776			2	576	1	288
Summer School (6 weeks) 12:00 - 4:00 p.m. (week days)	30	4	120	90	3,240	1	120	2	240		
4:00 - 10:00 p.m. (week days)		6	180	40	2,160			1	180	1	180
Pre-Post Summer School (10 weeks) 8:00 - 4:00 p.m. (week days)	50	8	400	90	10,800	1	400	2	800		
4:00 - 10:00 p.m. (week days)		6	300	40	3,600			1	300	1	300
8:00 - 4:00 p.m. (Saturdays)	10	8	80	40	960		—	1	80	1	80
Subtotal: Adult Education	306		2,448		57,696		520		4,336		1,928
TOTAL: Time Sharing			3,828		94,956		1,900		7,096		1,928

37,260 clock hours of tutorial instruction per year for school age children. Table 2 also indicates the amount of staff which would be required to operate and manage a system of this kind.

Adult education could be provided on the same system after school hours, during summer vacations, and on Saturdays. Experience has shown that the expected utilization level will vary between 40% and 90% for these kinds of instructional programs. The variance in utilization level is incorporated in Table 22 which shows a schedule for adult education use providing 57,696 tutorial hours of instruction per year and the staff which would be required to operate and manage this program. The combined use for public school education and adult education (Table 22) would result in 94,956 tutorial hours of instruction each year. This estimated number of tutorial hours is used throughout the remainder of this report for determining estimated costs per student station hour.

In addition to the instructional use of the system, the same computer can be used for the normal kinds of educational data processing jobs such as student scheduling, report cards, record keeping, attendance accounting, test scoring and analysis. Table 23 shows there would be 3,336 hours per year available for educational data processing.

Table 24 summarizes the computer system use and the staff requirements for operating the system for a calendar year.

Financing an Instructional Computer System

It is assumed that a school district would find it necessary to borrow the necessary funds to purchase a system of this kind and would therefore incur debt retirement costs. The most economical procedure would, of course, be a cash purchase. However, the problem of cash flow may not make the most economical plan the most feasible. Several plans are presented for comparison.

Resources would be required to meet the following needs:

1) purchase price;
2) maintenance; and
3) interest.

Table 23

Dedicated Computer System Use Schedule
and Staff Requirements

Schedule	Days	Hrs./Day	Total Clock Hours	Staff on Duty: Manager Qty.	Manager Hours	Proctor Qty.	Proctor Hours	Operator Qty.	Operator Hours
CAI Applications									
10:00 - 12:00 noon	260	2	520					1	520
4:00 - 6:00 p.m.	46	2	92					1	92
Subtotal: CAI Applications	306		612						612
Educational Data Processing									
12:00 - 8:00 a.m.	260	8	2,080					1	2,080
7:00 - 8:00 a.m.	46	14	644					1	644
Subtotal: Educational Data Processing	306		2,724						2,724
TOTAL: Dedicated System Use			3,336						3,336

Table 24

Summary of Computer System Use and Staff Requirements

Mode of Use	Clock Hours	Student Station Hours	Staff Hours: Manager	Staff Hours: Proctor	Staff Hours: Operator
Time Shared Mode	3,828	94,956	1,900	7,096	1,928
Dedicated Mode	3,336				3,336
TOTAL	7,164	94,956	1,900	7,096	5,264

There are an infinite number of ways of financing the purchase and maintenance of a computer system but four financial plans which might be typical for school districts in Pennsylvania are presented in Table 25. School law in Pennsylvania provides that school boards may borrow funds for up to five years without a special bond issue. Beyond that time, a bond issue must be secured. Interest rates depend upon the credit rating of the school district, the national economy at the time, and the number of years required to retire the debt. The interest rates and time periods reported in Table 25 appear to be reasonable estimates at the time of this report. Again the equipment components are classified according to their use in the system so that appropriate hourly rates can be established. Table 25 shows the prorated annual cost for fifteen years with interest bearing loans for equipment purchase for five years at 3.9%, and ten, twelve, and fifteen years at 5.5%. The total annual cost was derived by adding the purchase price, the maintenance cost for fifteen years, and the interest costs for the period of the loan together and dividing by the fifteen years established as the useful life of the system. This does not indicate the actual annual costs but rather the prorated annual costs over fifteen years. Obviously, a five-year loan at 3.9% is less costly than a fifteen-year loan at 5.5%.

Table 25

Prorated Annual Cost for 15 Years With Interest Bearing Loans for Equipment Purchase for 5 Years at 3.9% and 10, 12, and 15 Years at 5.5%

			Terms of Financing							
			5 yrs. @ 3.9%		10 yrs. @ 5.5%		12 yrs. @ 5.5%		15 yrs. @ 5.5%	
Equipment	Purchase Price	Maint. Cost: 15 Years	Total Interest	Annual Cost 1/15 x (1+2+3)	Total Interest	Annual Cost 1/15 x (1+2+5)	Total Interest	Annual Cost 1/15 x (1+2+7)	Total Interest	Annual Cost 1/15 x (1+2+9)
Common Components: Dedicated and Time Shared Modes	$247,150	$107,955	$ 25,832	$ 25,396	$ 75,706	$ 28,721	$ 91,874	$ 29,799	$115,579	$ 31,379
Components for Dedicated Mode Only	25,150	13,680	2,629	2,764	7,704	3,102	9,349	3,212	11,761	3,373
Components for Time Shared Mode Only (Without Audio)	281,365	174,150	29,409	32,328	86,185	36,113	104,593	37,341	131,579	39,140
Components for Time Shared Mode Only (With Audio)	409,165	471,150	42,766	61,539	125,332	67,043	152,101	68,828	191,345	71,444
GRAND TOTAL: (Without Audio)	553,665	295,785	57,870	60,488	169,593	67,936	205,817	70,351	258,920	73,891
GRAND TOTAL: (With Audio)	$681,465	$592,785	$ 71,227	$ 89,698	$208,740	$ 98,866	$253,325	$101,838	$318,685	$106,196

Hourly rates. Table 24 shows that the computer system would be used a total of 7,164 clock hours per year--53% of the time in a time shared mode and 47% of the time in a dedicated mode. Figure 14 shows the formulas which were used in the computation of hourly rates for dedicated system use and time shared system use.

Dedicated System Rate*

$$\frac{(.47 \times \text{Common Component Cost}) + \text{Dedicated Component Cost}}{\text{Annual Clock Hours of Dedicated Use}}$$

Time Shared System Rate*

$$\frac{(.53 \times \text{Common Component Cost}) + \text{Time Shared Component Cost}}{\text{Annual Student Station Hours}}$$

Fig. 14. Formulas used in the computation of hourly rates for dedicated and time shared system use.

*All costs cited include purchase price, interest on indebtedness and maintenance prorated for 15 years.

Table 26 illustrates the application of these formulas to the four plans of debt retirement which were presented in Table 25. As can be seen in Table 26, the rate for student station use ranges from $.78 to $.92 per hour and the rate for dedicated use ranges from $4.40 to $5.43 per hour depending upon the terms of financing.

Cash flow. Perhaps of as much or more importance than the cost per student station hour and the cost per dedicated hour is the annual cash flow required for each of the proposed financing plans. The annual cash flow without audio and with audio for each of the projected terms of financing is presented in Table 27. It is interesting to note that after the equipment has been purchased and the indebtedness retired, it costs only $.22 with audio and $.11 without audio for each student hour of instruction.

Calculations Leading to a Time Shared Student Station Rate and a Dedicated System Rate Prorated for 15 Years With Interest Bearing Loans for Equipment Purchased for 5 Years at 3.9% and 10, 12, and 15 Years at 5.5%

Equipment	5 yrs. @ 3.9%		10 yrs. @ 5.5%		12 yrs. @ 5.5%		15 yrs. @ 5.5%	
	Time Shared Costs	Dedicated Costs	Time Shared Costs	Dedicated Costs	Time Shared Costs	Dedicated Costs	Time Shared Costs	Dedicated Costs
Common Components: Dedicated and Time Shared Modes (Time Share 53%, Dedicated 47%)	$13,460	$11,936	$15,222	$13,499	$15,793	$14,006	$16,631	$14,748
Components for Dedicated Mode Only		2,764		3,102		3,212		3,373
Component for Time Shared Mode Only	32,328		36,113		37,341		39,140	
Hourly Rate (Without Audio)	0.48		0.54		0.56		0.58	
Components for Time Shared Mode	61,539		67,043		68,828		71,444	
Hourly Rate (With Audio)	0.78		0.86		0.89		0.92	
Dedicated Costs		14,700		16,601		17,218		18,121
Hourly Rate		4.40		4.97		5.16		5.43

Table 27

Annual Cash Flow for the Term of the Loan and Thereafter

	Terms of Financing			
	5 yrs. @ 3.9%	10 yrs. @ 5.5%	12 yrs. @ 5.5%	15 yrs. @ 5.5%
Annual Cash Flow Without Audio:				
Term of Loan	$142,026	$ 92,045	$ 83,009	$ 73,891
Thereafter	19,719	19,719	19,719	19,719
Annual Cash Flow with Audio:				
Term of Loan	$190,057	$128,540	$117,418	$106,196
Thereafter	39,519	39,519	39,519	39,519

CHAPTER V

OUTCOMES OF THE CONSORTIUM

For any project which includes multi-faceted activities during a span of over three years, it is difficult to precisely define a list of strengths and weaknesses which represent a final appraisal of that project. The myriad details which could be cited are partially reflected in earlier chapters; such details, however, do not provide a clear summary of what the impact of the project has been during its life-span and of what the impact might be on future projects. The purpose of this chapter is to discuss concisely the six major outcomes of the Consortium.

The project was a learning experience--a feasibility study to determine whether a Consortium is a viable strategy for developing curriculum materials tailored for specific locations; and a development project in which students in those locations would test those materials. The primary focus should be on the curriculum construction process. The success of the project will be measured in part by the impetus which can be derived for future CAI curriculum development projects.

1. This project has constructed more CAI curriculum materials for secondary education than any other project known to the authors. The average time to complete the on-line portions of GENMA and ALGEB is 150 hours.

The curriculum material must be considered to be a rough draft--like the mimeographed field-trial edition of a textbook. It includes many good segments, but it also includes some unpolished segments; some portions are of high calibre, other portions are deficient from a mathematical and/or a pedagogical point of view. In our judgment, however, the courses in their present state are <u>usable with caution</u> for operational instruction in high schools.

Content objectives--the perogative of the participating schools--were not always carefully thought-out and specified, nor were teaching strategies always clearly delineated and consciously selected with regard to specified objectives. Undoubtedly such strategy selection requires a research base which was unavailable beforehand, and, due to production deadlines, impossible to construct within the project. Potential users must ascertain whether or not the content objectives of the course (not totally identified), are in agreement with their objectives. Clearly defined instructional objectives are necessary for a) determination of content, and b) selection of teaching strategies. The courses do have a major advantage with respect to content, however, and that is their potential to be completely and thoroughly reviewed by a qualified specialist.

2. The courses need to be revised and articulated with a set of evaluation instruments focused on student mastery. The present instruments (the non-normed and normed achievement tests) were developed following a norm-referenced pattern, and the relatively low scores reflect this orientation. Consider the average percentage of increase from pretest to posttest, from roughly 40 percent to 60 percent. This finding indicates one of two things: 1) that the evaluation instruments were not built to the specifications for criterion-referenced tests, or 2) that the courses .re not teaching for mastery. The first possibility, which involves the simpler revision, must be tested first, by building sets of criterion-referenced instruments designed to measure precisely the content-objectives for each course. The course material then should undergo another field trial to measure achievement with these instruments, within a carefully-constructed evaluation plan.

3. To try to insert an individualized program of the type developed by the Consortium into schools with widely divergent philosophies of mass education is not recommended. Other subjects are being taught following a traditional pattern, with traditional expectations. Students carry-over behavior patterns and attitudes from those other courses. For instance, the students had some difficulty adjusting to the relative freedom of the CAI classroom, where each learner was working individually to master content. Use of a variety of materials, and continuous interaction with those materials, is at the core of the individualized philosophy inherent in CAI--the focus is on the learner and on self-directed learning. This is far different from the traditional classroom where all students are expected to sit and listen to the teacher present a specified body of content which all will then practice: the focus in the traditional classroom is on the content, not on the learner.

Teachers also had many of the same expectations of CAI as they had for the traditional approach. Their comments (presented in Appendix Q) reflect this fact: they were concerned, for instance, because not all students covered the material in the given amount of time. In future programs more stress must be placed on teacher orientation to individualized instruction and role change in the classroom.

Computer-generated student progress reports were developed (see Chapter III), but were not fully used by teachers. This is an important aid to the teacher in planning for individualized instruction with off-line materials as well as with on-line programs. Teachers need more guidance in how to use these reports--how, in fact, to individualize instruction.

The school is a social system, and produces better results when the way in which all courses are taught is in agreement with its general overall philosophy. A fundamental organization of schools is needed in order to adapt them to new individualized methodologies.

4. The course materials must be revised for a program of continuous progress instead of the current restrictions of the semester or bi-semester plan of scheduling. Students should not be taught as a class, but as individuals. An open curriculum plan of organizing students for learning--or organizing learning-content for students--must be articulated.

The continuous progress plan has a ready-made grading system: students don't get academic credit for materials not mastered, just because they sat in class.

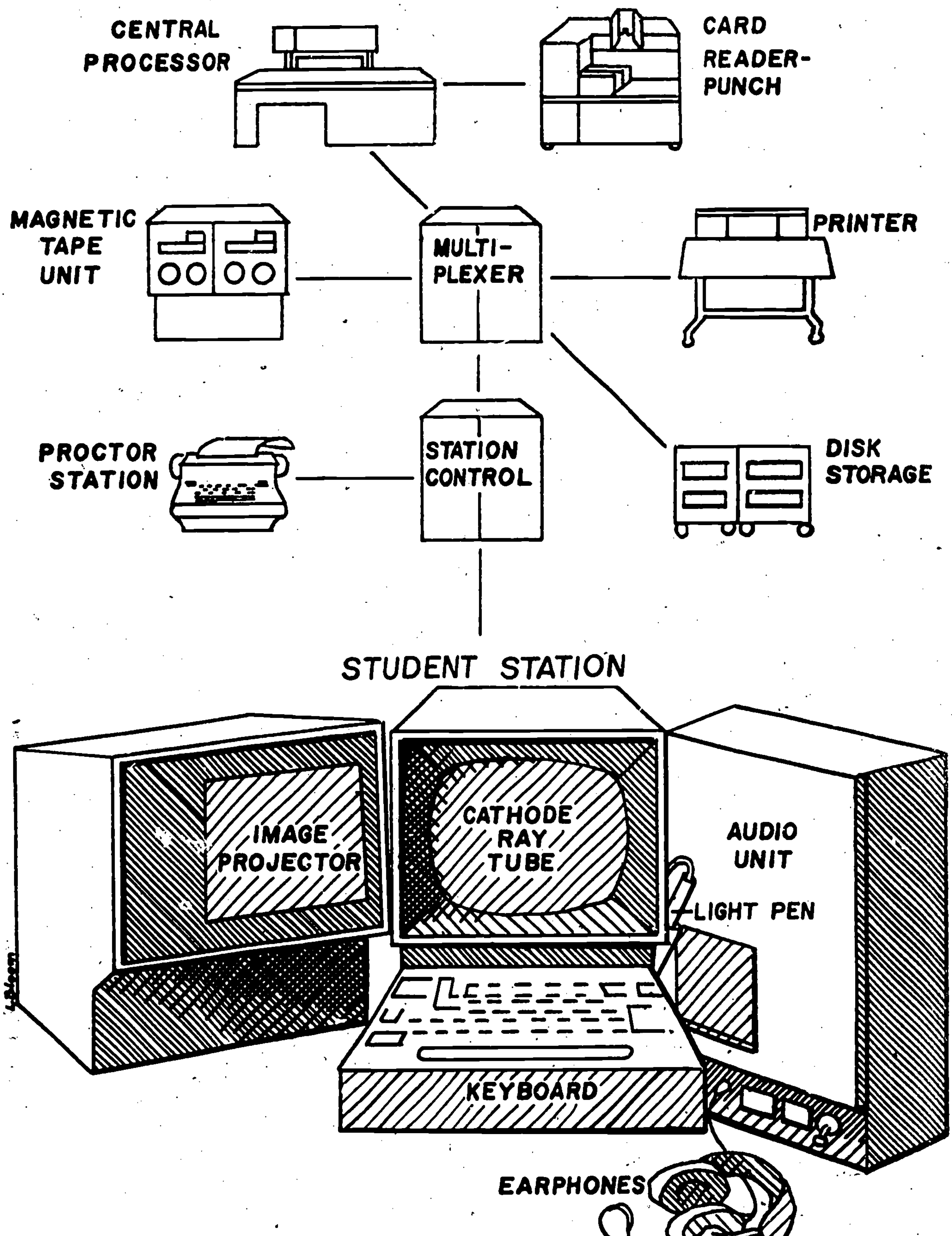
5. Because of curriculum storage limitations of the computer system, improved management or blocking of the course material is needed. The amount of material available on any one day must be better-matched to the needs of students. One alternative is to group students according to total progress and to make time available to them on that basis. It is too ambitious to schedule two students per terminal during each period. There would be better utilization of the system if the number of students assigned to the program at any one time equalled the number of terminals. In this way as some students finished the course, others who were ready for intensive self-directed learning could begin.

6. Off-line materials, with the exception of some worksheets, were not used effectively. Generally, neither enrichment nor remedial materials were used individually; instead, all students were expected to complete virtually the same off-line materials. Again, expectations of teachers, accustomed to having all students cover the same textbook content, precluded differentiating instruction to a significant degree. Further investigation into the appropriate interrelationship between on-line and off-line materials appears warranted. Consideration should be given to incorporating topics, now in off-line format, into on-line exercises and into inquiry oriented problems. This modification is consistent with Recommendation #4 concerning a shift in the utilization patterns from class progress to individual progress.

7. This project demonstrated that it is possible and advantageous to create consortia of public schools, universities, and state education departments for the purpose of developing and evaluating curricular material. These involved non-profit agencies can, by working cooperatively, exercise the leadership focused on change so desperately needed today in American education.

APPENDIX A

PICTORIAL DIAGRAM OF IBM 1500 INSTRUCTIONAL SYSTEM


CENTRAL PROCESSOR
CARD READER-PUNCH
MAGNETIC TAPE UNIT
MULTI-PLEXER
PRINTER
PROCTOR STATION
STATION CONTROL
DISK STORAGE
STUDENT STATION
IMAGE PROJECTOR
CATHODE RAY TUBE
AUDIO UNIT
LIGHT PEN
KEYBOARD
EARPHONES

APPENDIX B

COURSEWRITER II PROGRAMING

FILMED FROM BEST AVAILABLE COPY.


```
**GENMA 110 PL0090          PL090A        085 02005   S
PL0090*E
   1 PR   *E
$$ 2 NO   (B)LK. 3, (P)RACTICE(& L)INE (G)RAPHS*E
   3 LR   PL0090+/RR1*E
   4 PRR  *E
   5 BR   ON+/S31+/1*E
   6 DE   0+/32*E
$$ 7 NO   FP1108*E
   8 FP1  158*E
   9 DT   0,0+/2,0+/40,0+/(L)OOK AT DISPLAY 1108.*E
  10 PA   30*E
  11 DT   4,0+/2,4+/40,0+/(W)HAT TYPE OF GRAPH IS SHOWN(/*E
  12 EPI  4,29+/2,4+/11,29+/+/99+/PL0090A1K1*E
  13 FN   ED+/+/,D+/+/ +,,+/.+/*R+/*I+/*B*E
  14 FN   ED+/+/+/L+/1*E
  15 WA   +/W-*E
  16 CA   LINE+/C1*E
  17 CB   LINEGRAPH+/C2*E
  18 DE   8+/18*E
  19 DT   6,12+/2,6+/28,12+/(R)IGHT.*E
  20 PA   30*E
  21 WA   BAR+/W1*E
  22 WB   BARGRAPH+/W2*E
  23 DT   8,0+/4,8+/40,0+/(N)O, HERE A LINE*B*B*B(-*B*B- -- )IS USED TO SHOW DATA.*E
  24 PA   30*E
  25 WA   PICTURE+/W3*E
  26 WB   PICTUREGRAPH+/W4*E
  27 DT   8,0+/4,8+/40,0+/(I)SN'T A LINE*B*B*B*B(---- )USED TO SHOW DATA(/*E
  28 UN   +/U*E
  29 DT   8,0+/4,8+/40,0+/(S)O FAR WE'VE LOOKED AT 3 TYPES OF*C*IGRAPHS.  (W)HICH IS THIS(/*E
  30 PA   60*E
  31 UN   +/U*E
  32 DT   8,0+/4,8+/40,0+/(A )LINE*B*B*B*B(---- )SHOWS THE COMPARISON OF DATA.*E
  33 PA   30*E
  34 NX   *E
  35 DT   6,0+/4,6+/40,0+/(D)ISPLAY 1108 SHOWS A (LINE GRAPH).*E
  36 PA   30*E
  37 PR   *E
  38 DE   6+/2*E
  39 DT   11,0+/2,11+/40,0+/(W)HAT IS THE TITLE OF THE GRAPH(/*E
  40 EPI  13,0+/2,13+/40,0+/+/99+/PL0090B1K1*E
  41 FN   ED+/+/,D+/+/ +/,+/.+/('+/*R+/*I+/*B*E
  42 DE   15+/4*E
  43 WA   +/W-*E
  44 CA   CIGARETTESSMOKEDPERPERSON+/C1*E
  45 DT   15,0+/2,15+/40,0+/(V)ERY GOOD.*E
  46 PA   30*E
  47 CA   CIG(8+/)C2*E
  48 DT   15,0+/2,15+/40,0+/(O).(K).*E
  49 PA   30*E
  50 DT   13,0[illegible]13+/40,0+/(T)HE FULL [illegible]E IS(&*C*I    (C)IGARETTES (S)MOKED (P)ER [illegible]RSON(').*E
  51 PA   40*E
  52 UN   +/U*E
```

```
53 OT   15,0+/4,15+/40,0+/(L)OOK AT THE TOP OF THE GRAPH*C*IFOR THE TITLE.*E
54 PA   30*E
55 NX   *E
56 DT   15,0+/4,15+/40,0+/(T)HE TITLE IS(&*C*I'C)IGARETTES (S)MOKED (P)ER (P)ERSON('*E
57 PA   30*E
58 PR   *E
59 OTI  30,32+/2,30+/5,32+/*0+R+R+E+S+S*E
60 PAE  *E
61 DTI  30,32+/2,30+/5,32+/*E
62 DT   18,0+/4,18+/40,0+/(L)ET'S LOOK AT THE SCALE USED. *E
63 PA   20*E
64 DT   20,2+/2,20+/40,0+/1 UNIT = (----  )CIGARETTES.*E
65 PA   30*E
66 EPI  20,11+/2,20+/4,11+/+/99+/PL0090C1K1*E
67 FN   E0+/+/,0+/+/ +/,+/.+/*R+/*I+7*B*E
68 FN   ED+/+/+/0+/0*E
69 FN   ED+/+/+/1+/L*E
70 WA   +/W-*E
71 CA   100+/C1*E
72 OE   22+/9*E
73 OT   22,0+/2,22+/40,0+/(G)REAT(6 K)EEP UP THE GOOD WORK.*E
74 PA   30*E
75 WA   3800+/W1*E
76 OT   22,0+/6,22+/40,0+/(N)O, 3800 IS THE FIRST DIVISION.*C*I(S)UBTRACT IT FROM THE SECOND DIVISION*C*ITO GE THE VAL
        UE OF THE UNIT USED.*E
77 PA   30*E
78 UN   +/U*E
79 DE   22+/6*E
80 DT   22,0+/4,22+/40,0+/(S)UBTRACT ONE UNIT ON THE VERTICAL SCALE*C*IFROM THE NEXT ONE TO FIND THE ANSWER.*E
81 PA   30*E
82 UN   +/U*E
83 DT   28,0+/4,28+/40,0+/(F)OR EXAMPLE, USE THE FIRST 2 DIVISIONS(&*C*I      (3900-3800=?/*E
84 PA   30*E
85 NX   *E
86 OTI  20,11+/2,20+/4,11+/100*B*B*B(---*E
87 PA   30*E
88 PR   *E
89 DTI  30,32+/2,30+/5,32+/*0+P+R+E+S+S*E
90 PAE  *E
PL090A*E
 1 LO   0+/C16*E
 2 OE   4+/28*E
 3 OT   3,0+/4,3+/40,0+/(W)E CAN USE A LINE GRAPH TO STUDY A*C*IGENERAL PATTERN IN OUR DATA.*E
 4 PA   50*E
 5 DT   8,3+/4,8+/37,3+/(T)HE GENERAL DIRECTION OF THE LINE*C*I  "SHOWS THE (TREND).*E
 6 PA   20*E
 7 DTI  10,13+/2,10+/6,13+/*E
 8 PA   5*E
 9 DTI  10,13+/2,10+/6,13+/(TREND).*E
10 PA   5*E
11 DTI  10,13+/2,10+/6,13+/*E
12 PA   5*E
13 DTI  10,13+/2,10+/6,13+/(TREND).*E
14 PA   30*E
```

```
15 DT   14,1+/4,14+/39,1+/(F)OR EXAMPLE, DURING L964, THE LINE IS*C*I GENERALLY*E
16 DT   19,2+/2,19+/38,2+/*G+M+O+V+I+N+G+,*B,+U+P    +M+O+V+I+N+G+,*B,+D+O+W+N    +N+O+T+,*B,+M+O+V+I+N+G*E
17 EPP  +/PL0090DIK1*E
18 CAP  2,19,11,29+/C1*E
19 DT   19,2+/2,19+/38,2+/*O+M+O+V+I+N+G+,*B,+U+P    +M+O+V+I+N+G+,*B,+D+O+W+N    *INCT MOVING*E
20 BR   PR1+/C6+/G+/O*E
21 DT   22,0+/2,22+/40,0+/          (V)ERY GOOD(6*E
22 PA   30*E
23 BR   PR2*E
24 WAP  2,19,11,14+/W1*E
25 DTI  19,14+/2,19+/11,14+/MOVING DOWN*E
26 AD   1+/C16*E
27 DT   22,0+/2,22+/40,0+/(N)O, TRY AGAIN.*E
28 PA   30*E
29 DE   22+/2*E
30 WAP  2,19,9,2+/W2*E
31 DTI  19,2+/2,19+/9,2+/MOVING UP*E
32 AD   1+/C16*E
33 DT   22,0+/2,22+/40,0+/(N)O, TRY AGAIN.*E
34 PA   30*E
35 DE   22+/2*E
36 WAP  32,0,40,0+/ZZ*E
37 DT   22,0+/2,22+/40,0+/(O)FF TARGET.  (T)RY AGAIN.*E
38 PA   30*E
39 PR   *E
40 DT   22,0+/2,22+/40,0+/          (O).(K).*E
41 PA   30*E
42 PR   *E
43 DT   22,0+/2,22+/40,0+/ (S)O WE WOULD SAY THE (TREND*B*B*B*B*B----- )IS*E
44 PA   10*E
45 DT   25,6+/2,25+/34,6+/*O+U+P+W+A+R+D    +O+O+W+N+W+A+R+D    +N+O+,*B,+C+H+A+N+G+E*E
46 PA   10*E
47 EPP  +/PL0090E1P1*E
48 CAP  2,25,9,26+/C1*E
49 DT   25,6+/2,25+/40,0+/*O+U+P+W+A+R+D    +D+O+W+N+W+A+R+D    NO CHANGE*E
50 DT   28,0+/4,28+/40,0+/          (R)IGHT(6*E
51 PA   30*E
52 WAP  2,25,6,6+/W1*E
53 DTI  25,6+/2,25+/6,6+/UPWARD*E
54 DT   28,0+/4,28+/40,0+/  (N)O, AN UPWARD TREND*B*B*B*B*B*B*B*B*B*B*B*B(------ ----- )WOULD MEAN THAT*C*I  THE LINE
        IS GENERALLY GOING UP.*B*B*B(--*E
55 PA   30*E
56 WAP  2,25,8,15+/W2*E
57 DTI  25,15+/2,25+/8,15+/DOWNWARD*E
58 DT   28,0+/4,28+/40,0+/  (N)O; A DOWNWARD TREND*B*B*B*B*B*B*B*B*B*B*B*B*B*B(-------- ----- )WOULD MEAN THAT*C*I  TH
        E LINE IS GENERALLY GOING DOWN.*B*B*B*B*B(----*E
59 PA   30*E
60 WAP  32,0,40,0+/ZZ*E
61 DT   28,0+/4,28+/40,0+/(O)FF TARGET.  (T)RY AGAIN.*E
62 PA   30*E
63 PR   *E
64 DT!  30,32+/2,30+/[illegible]+R+E+S+S*E
65 PAE  *E
```

APPENDIX C

SPECIAL ROUTINES AND ON-LINE TESTS

SPECIAL ROUTINES

The following routines have been developed for special purposes in the Coursewriter program. They are unique to the Consortium CAI program.

ON routine

This routine initializes and updates the counters, switches, return registers and buffers used to acquire data for the Student Performance Summary for each day's on-line activity (one or more sign-on's). Each time the student signs on the program, the on routine is executed first.

The skip routine is accessed from the on routine as described in the GENERAL OPERATING PROCEDURES (**see page 100**).

Note: If a student is signed-off with message code 41 (label not found in return register) just after he signs on, it is likely that the error is generated from the branch to return register 1 executed at the end of the on routine. The PRESS to access the skip routine is executed before the branch instruction. It can be used to "skip" the student around the branch. The label displayed by the skip routine is the invalid label causing the error. The correct version of the label should be typed in the skip routine.

SKIP routine

This routine permits immediate access to any label within the course segment being executed. (By accessing the label "trans," the program is transferred to the next logical course segment. By accessing the label "begin," the program is transferred to the course index.) The skip routine identifies the current course segment* and the last executed major label*. It allows for entry of a comment* and then the desired label*. When this label is entered, the program resumes execution at that label. A proctor message containing the starred items is sent.

Procedures for accessing and using the skip routine are described in the GENERAL OPERATING PROCEDURES. This routine should not be available for student use.

OFF routine

This routine processes data accumulated during time on-line for the Student Performance Summary and is accessed by initiating the sign-off procedure for student mode as described in the GENERAL OPERATING PROCEDURES. For this routine to be executed, it is absolutely essential that the student use correct sign-off procedures. If the Off routine is not executed, incorrect information will be given in the SPS report for the "guilty" student. The most important errors that may be incurred by incorrect sign-off procedures are: incorrect information given for block number and assignments, and in appropriate label used for restart point.

The Skip routine may be accessed from the Off routine as described in the GENERAL OPERATING PROCEDURES.

OPTION routine

If a student fails to meet criterion on an out-quiz, he is presented the DECISION TABLE which gives him the option to review any part of the instructional materials (instruction, practice, summary) covered by the out-quiz or to sign-off. If the student takes the option to sign-off, he will begin at the DECISION TABLE when he signs on again.

While executing his option, the student can return to the DECISION TABLE at any time by initiating sign-off procedures. If the student reviews all the material in his option, he is automatically branched back to the DECISION TABLE. In either case, the DECISION TABLE will then contain the out-quiz as an additional option. (See Flowchart, Appendix H.)

STUDENT PERFORMANCE SUMMARY

The Student Performance Summary (SPS) is a computer program that extracts data that has been stored for each student in the disk files. The information provided by SPS is designed to assist teachers in monitoring student progress and managing the CAI classroom.

The SPS program can only be executed when students are not on-line. It should be run as soon as possible after all students in a course are finished for the day so that the information can be made available to teachers for planning the next day's activities.

Note: If the <u>Off</u> routine described earlier is not properly executed, data for SPS will be lost.

Student Performance Summary

COURSE -- GENMA   SECTION -- 1   TIME -- 15/07   DATE -- 10/14/1970

STUDENT NAME	NUM	SEG	SCT.BK	LABEL	DAILY TIME**	LAST TIME**	CUML TIME	PRESKL TEST* **	PRE TEST* **	OUT QUIZ* **	ASSIGNMENT* **	CHAPT TEST	ATTEND ON-LINE
JOHN STURDIVANT	sljs	1	01.01	e00010	0	0	34					0	1
JOHN JONES	sljj	2	01.01	n00010	28	28	320	99	0	3		0	14
MARY ADAMS	slma	20	05.05	n00240	15	15	348	99	-1	1	5a	0	21
ALICE ARBECK	slaa	22	09.09	n00650	25	25	285	99	0	2	1b	0	18
SAM TARRIS	slst	22	11.11	n00770	18	10	325	99	1	1	10a, 11a	0	20
SALLY HAIRE	slsh	29	CH2CHT	CT02	30	30	380	0	0	0		75	20
TOM DORMAN	sltd	4	05.05	d00090	20	5	300	99	0	0	5a	0	14

Code	Column	Interpretation
99	PRESKIL, PRETEST, OUT QUIZ	No test
0	PRESKL	Began test but did not finish.
1	PRESKL	Missed at least 1 question on test.
-1	PRETEST	Test available but option not taken.
0	PRETEST	Criterion not met on test.
1	PRETEST	Criterion met on test.
0	OUT QUIZ	Began test but did not finish.
1,2,3	OUT QUIZ	Number of times out quiz was completed.

*These do not apply when a Chapter Review Test or a Chapter Test is taken.

**These items are set to zero each time SPS is run.

Interpretation of Headings in the Student Performance Summary

Heading	Interpretation
STUDENT NAME	Student name
NUM	Student number
SEG	Course segment number
SCT.BK*	Section and block number These numbers will be the same in genma. In algeb, section refers to the section number in the original version of the course.
LABEL	Last major label encountered during execution of the program
DAILY TIME**	The total time, in minutes, of the daily terminal session or sessions.
LAST TIME**	If a student has signed on more than once per period this column indicates the length of time, in minutes, of the last session.
CUML TIME	The cummulative time, in minutes, on the course.
PRESKL TEST**	Preskills test for one or more instructional blocks.
PRE TEST**	Pretest for one or more instructional blocks.
OUT QUIZ**	Criterion quiz for an instructional block.
ASSIGNMENT**	Specifies off line activity associated with an instructional block.
CHAPT TEST	Percent correct on a chapter test.
ATTEND ON-LINE	Number of days a student has been signed on the course.

*Chapter Review Test or Chapter Test identified in this column.

**These items are set to zero each time SPS is run.

See documentation of SPS for explanation of sorting.

On-line Chapter Test

Tests have been developed for on-line administration at the end of each chapter for each course. (The one exception is Chapter 3 in general mathematics.) The test items parallel the format and content of questions presented in the instructional portion of the program, and the on-line quizzes. The chapter tests should be viewed as criterion tests for the chapters. If a student's preformance is unsatisfactory, the areas of difficulty may be identified by the teacher and remedial activities prescribed.

Each chapter test consists of a series of pools of test items. Test items are representative questions from the various blocks in a chapter. Items from one or more blocks are stored in a pool. Not all items in a pool are to be presented to the student taking the test. For example, there may be five test items from the first block of a chapter in an item pool, but the student would receive only three of the items. The Coursewriter program randomly selects items from the pool and presents them in a random order. The probability of the same test items being presented in the same sequence by the program is greatly reduced by using this technique.

The student is provided with three options as each item is presented. The student may respond to the item, skip to the next item, or return to a previously presented item. If the student elects to redo an item, after a response is made to that item, the program will return to the last item presented. The student is given no knowledge of results during the execution of the test. At the end of the test, the student may return to a previously presented item, having the skipped items presented again, or have his score displayed.

Each item in the pool is identified by an alphanumeric code. The alphabetic character identifies the section pool, the number character is the number of the item within a section pool. For example, c2 identifies the item as the second question in section pool c. A printed copy of each chapter test is available to the teacher. The items in the test are identified by the alphanumeric code.

At the end of the test a proctor message is printed out at a typewriter terminal giving a summary of the student's performance, a list of the alphanumeric code of the studerts test questions and an indication below each question of his performance on that item. (See Figure 15.)

```
station 04 slrt genma proctor message
test          cor        pbm     %      min
ct04           6          10     60      6
**b4cla5alc4b3a3c2b5
***  b a    -
```

test - identifies the test

cor - the number of questions responded to correctly

pbm - the total number of problems presented

% - (cor/pbm) x 100

min - the time on test, in minutes

The flagged items are interpreted as follows:

* - indicates an incorrect keyboard response to item b4

b - indicates the incorrect selection from a multiple choice item, a5, by light pen

a - indicates the incorrect selection from a multiple choice item, al, by light pen

\- - indicates item a3 was skipped

Figure 15. Proctor message of a student's performance for one terminal session.

In this example, the teacher can determine that the student has missed the items from section a. Further instruction on the material for section a could be provided and the student retested.

Review Questions in Chapter Tests

Each chapter test after chapter 1 has approximately five review questions* which cover the material learned in previous chapters. As the name indicates, the purpose of these questions is review.

*These review questions are not to be confused with the review test which is a randomly generated test of items which parallel the chapter test. The review test is given the day before the chapter test.

After the student has completed the chapter test, and has been given his score, he is told that he is to answer several review questions. He is given the option of doing them immediately or the next day when he signs on again. Depending on his choice, the student is either given the review questions and then signed off or given the message that he will do the questions the next day and signed off.

Each student gets the same review questions in the same order. Unlike the chapter-test questions, the student is given the correct answers if he answers incorrectly. At the end of the review the student is told how many questions he has answered correctly. This score is not stored or combined in any way with the regular chapter-test score.

For programing convenience, the coding of the review questions has been placed in the segment containing the chapter-test (after the test questions) and in the first segment of the following chapter (after the <u>on</u> routine). A switch is used to control course flow so the student receives the questions only once.

<u>Review Chapter Test</u>

A review of the instructional material, in the form of a preview of the forthcoming chapter test, is provided at the end of each chapter. (The one exception is Chapter 3 in the general mathematics course.) The items in the Review Chapter Test parallel selected samples from the item pools in the corresponding Chapter Test.

At the completion of the Review Chapter Test, students are signed off. The program does not permit students to sign on the Chapter Test the same day that the Review Chapter Test was taken. The reason for the delay is to provide students with an opportunity to review prior to taking the Chapter Test. It is also unlikely that both tests could be completed in one class period.

When a student is signed off, a proctor message similar to the one for a Chapter Test is delivered to the typewriter terminal. A printed copy of the Review Chapter Test enables areas of difficulty to be identified and review materials to be assigned. It is recommended that students do the assigned work prior to taking the Chapter Test.

Course Index

Course segments ALGEB - Ø and GENMA - Ø contain indices of the respective courses. A Course Index may be accessed from any segment in the course by using the SKIP routine (see page 101).

Each Course Index provides three options: 1) access to an index of the chapters, 2) access to an index of course segments ordered by chapter, 3) direct access to a course segment.

Chapter index. The user may see a complete list of chapter topics and/or access the segment index of the chapter of his choice. Access of the segment index is by a light pen response.

Segment index. The user may see a complete list of the course segments within each chapter and/or access a course segment. The segment index includes the segment numbers and the topics of course content included in the segments. A course segment is accessed by a light pen response.

Direct access. If the user knows the number of a desired course segment without referring to an index, the segment may be accessed by entering the appropriate number.

INSTRUCTIONAL STATION

GENERAL TERMINAL PROCEDURES

ATTENTION*	Operation:	1.	press and hold ALTN CODING key
		2.	press INDEX key
	Purpose:	1.	to gain control of the keyboard to type a command
		2.	to cause the course to pause
CHARACTER-ERASE	Operation:	1.	press and hold ALTN CODING key
		2.	press BACKSPACE KEY until cursor (□) is in the desired position
	Purpose:		to erase one or more typed characters
ENTER	Operation:	1.	press and hold ALTN CODING key
		2.	press SPACE BAR
	Purpose:	1.	to indicate the end of a response or a command
		2.	to cause the course to continue after an ATTENTION pause
INDEX	Operation:		press INDEX kay
	Purpose:		to move the cursor (□) down one half-line for each press of the INDEX key
~~PRESS~~	Operation:		press the SPACE BAR
	Purpose:		permits the course to continue
REVERSE INDEX	Operation:		press REV INDEX key
	Purpose:		to move the cursor (□) up one half-line for each press of the REV INDEX key
SIGN-ON	Operation:	1.	ATTENTION (ALTN CODING and INDEX simultaneously)
		2.	type: on (space) course name/author (or student) number
		3.	ENTER (ALTN CODING and SPACE BAR simultaneously)
	Purpose:		to sign on a CAI course

*Do not make this procedure available to the student.

SIGN-OFF

Author Mode*

Operation:
1. ATTENTION (ALTN CODING and INDEX simultaneously)
2. Type: off**
3. ENTER (ALTN CODING and SPACE BAR simultaneously)

Student Mode

Operation:
1. One of the following:
   a. In DECISION TABLE: choose "off" option
   b. Any other light pen response: point to P in lower right corner of screen
   c. Keyboard response: type ALTN CODING q
2. Press SPACE BAR when PRESS appears on screen.

Purpose: To sign-off or terminate on instructional session

SKIP ROUTINE***

1. Accessible from
   a. Off routine
      1. Initiate sign-off procedure (Type ALTN CODING q, point light pen to P in the lower right corner of screen, or choose "off" option in DECISION TABLE)
      2. PRESS appears in lower right corner of screen.
      3. Although no cursor appears on the screen, type ALTN CODING p.
      4. If SPACE BAR is pressed (instead of typing ALTN CODING p), the program will continue through the off routine
   b. On routine (Student executes on routine each time he signs on.)
      1. Screen is cleared and PRESS appears in lower right corner of screen.
      2. Although no cursor appears on the screen, type ALTN CODING p.
      3. If SPACE BAR is pressed, the program will continue to the student's restart point.

---

*This procedure should not be made available to the student. Student use of this procedure will result in incorrect data on SPS.

**This may be changed periodically by the system's operator to prevent student use of this procedure.

***The skip routine should not be made available to the student.

2. Text displayed on screen
   a. Present course segment
   b. Last executed major label

3. Type comment
   a. Approximately 50 characters are available for comments
   b. If no comment, just ENTER.

4. Type label to access material in
   a. Current course segment - type label and enter
   b. Next logical course segment - type "trans" and enter
   c. Any other segment by means of the course index - type "begin" and enter

NOTE: If an invalid label is entered, an error message 41 (label not found in return register) will be generated and the terminal will be signed-off. When the student is signed back on, execution will begin in the <u>skip</u> routine.

APPENDIX D

DRILLS

REMAT AND DRILL

Two programs were developed to supplement the algebra and general mathematics courses. These supplemental programs were designed to provide drill and practice through mathematical games and drill exercises. Entry is governed by students' registering for "remat." An index at the beginning of the remat program provides access to the various exercises in the remat and drill course segment. The use of the ALTN CODING q or selection of p with the light pen will return the program to the index. To sign off, the "off" option in the index should be selected in order to obtain available proctor messages.

Remat

The remat course segment contains Tic-Tac-Toe, Algebra Drill, Estimation Game and Multiplication Drill.

Tic-Tac-Toe. The original game has been modified to incorporate drill with arithmetic operations. Two players take turns in marking a cell by pointing with the light pen to the desired cell. When a cell has been selected by a player, a problem is displayed on the screen. If the correct answer is given, the selected cell is marked by a X or O, whichever is appropriate. If an incorrect answer is given, the cell is not marked and the second player takes his turn. The sequence is repeated until all cells are marked. The winner or a draw is declared on the screen by the program.

The numbers for the problems are randomly generated. There is no limit to the number of games that may be played. No record is maintained of the number of games won by a player.

Estimation Game. This game was designed to provide practice in estimating the product of two whole numbers, each in the range $0 \leq n < 100$. The game aspect of the program is provided by a target with four concentric square rings. When a problem is posed, the target appears on the screen of the CRT. The closeness of response to the correct answer determines which ring is "lit up." An answer within 1/16 of the correct answer scores a bull's eye; 1/8 is indicated by the second ring; 1/4 is indicated by the third ring; 1/2 is indicated by the fourth ring. A response that deviates by more than 1/2 of the correct answer misses the target.

As an added motivational device, a score is generated that is dependent on the accuracy of the response and how quickly the response is made. Four points are scored for a bull's eye, three points for the second ring, two points for the third ring and one point for the fourth ring. In addition, 20 points are scored if the response is within one second. A time-point is lost for every second required to respond. For example, a perfect score of a bull's eye within one second is 4 + 20 = 24 points. A "hit" in the outer ring with a response time of 5.4 seconds would be 1 + (20 - 5) = 16 points. The score is multiplied by 100 to provide a large number and is displayed to the student.

A total score is kept for each student. After twenty problems his score is compared with his previous high score for twenty problems, then a new set of problems is started. Essentially, the student is playing the game against himself since scores between sets of problems are compared.

The scoring on a combination of time and accuracy forces the student to answer quickly in order to get a high score. The purpose of the game is to motivate students to estimate an answer, therefore, "educated guesses" are encouraged.

<u>Algebra</u> <u>Drill</u>. This program provides problems of the type j + 3 = 10 or 7k + 10 = 80. The variables and constants are randomly generated. The program may be considered an enriched drill since the algorithm for solving a problem is demonstrated if two incorrect answers are given. The feedback for incorrect answers is described below.

Problem: Solve the following:

7k + 10 = 80

1st incorrect answer feedback:

Check your answer. Try again.

2nd incorrect answer feedback:

Add -10 to both sides of the equation.
The resulting equation is
7k + 10 + (-10) = 80 + (-10)
which then becomes

7k = 70

Divide both sides by 7 to get

k = 10

Multiplication Drill. This program is a timed drill on the multiplication of integers which are randomly generated. Different levels of problems provide a challenge to the student to increase his proficiency by moving to more difficult levels containing problems with larger numbers and shorter time limits. The integers range from -99 to 99. Time limits range from 1.5 seconds to 7.0 seconds.

Drill

The drill course segment contains programs on: a) whole numbers operations, b) integers operations, c) a version of the Estimation game (Acu-Rate) utilizing the four arithmetic operations, d) inequalities between whole numbers, e) decimals and fractions, and f) reducing fractions.

An index at the beginning of the course segment permits access to the various programs in the segment.

Whole Number Operations. Drill-1 is an untimed mathematics drill in the addition, subtraction, multiplication, and division of positive integers. Addition contains 7 levels; subtraction, 6; multiplication, 7; and division, 6. The problems, which are randomly generated, become more difficult as the levels increase.

When the student signs on he will select an operation. The student will begin at the lowest level within that operation and will continue until he completes all levels or until he signs off. He will go to the next higher level when he correctly answers 5 randomly-generated problems in succession. If he misses one problem his score will go back to zero but he will remain on the same level. After receiving two new problems he will have another attempt at the problem he answered incorrectly. If he answers two problems in succession incorrectly he will return to the next lower level.

The proctor message will tell if the student completes all levels within an operation or if he signs off. The proctor message will also give the operation he was in, the last level he completed, the amount of time spent on the operation and the student's number.

Integers Operations. Drill-2 is an untimed mathematics drill in the addition, subtraction, multiplication and division of positive and negative integers. The levels and value limits are identical to Drill-1. The only difference between Drills 1 and 2 is that in Drill-2, levels 5 and up in each operation will contain both positive and negative integers. Drill-1 contains only positive integers.

Proctor messages are the same as in Drill-1.

Acu-Rate. Drill-3 is a version of the Estimation game. While estimation contains problems requiring the estimation of the product of two numbers whose ranges are -99 > n < 99, Acu-Rate is a set of problems which use one of the four arithmetic operations that is selected.

Inequalities. Drill-4 is a drill on relationships using whole numbers, decimals and fractions.

The student uses the light pen to point to the sign in the answer set that will indicate the relationship between the randomly generated numbers.

The following indicates the levels, the minimum and maximum values of the numbers to be randomly generated and the signs from which the student will choose. The box indicates where the missing sign is to be inserted.

Level	Problem	Answer Set
1	(0 - 10)* □ (0 - 10)	< = >
2	(0 - 50) □ (0 - 50)	< = >
3	(0 - 1000) □ (0 - 1000)	< = >
4	(0 - 5) + (0 - 5) □ (0 - 10)	< = >
5	(0 - 10) □ (0 - 5) + (0 - 5)	< = >
6	(0 - 5) + (0 - 5) □ (0 - 5) + (0 - 5)	< = >
7	(1 - 10) □ (1 - 10)	= ≠
8	(1 - 10) □ (1 - 10)	≤ ≥
9	(.000 - .999) □ (.000 - .999)	< = >
10	$\frac{1}{(1 - 10)} \square \frac{1}{(1 - 10)}$	< = >
11	$\frac{(1 - 10)}{(1 - 10)} \square \frac{(1 - 10)}{(1 - 10)}$	< = >
12	$\frac{(1 - 10)}{(1 - 10)} \square \frac{(1 \div 10)}{(1 - 10)}$	< = >

*The numbers in parentheses indicate the minimum and maximum numbers that will be generated.

Inequalities (Drill-4) continued

Level	Problem	Answer Set
13	$\frac{(1 - 10)}{(1 - 10)} \; \square \; \frac{(1 - 10)}{(1 - 10)}$	$< \; = \; >$
14	$(1 - 5) \; \square \; \frac{(1 - 10)}{(1 - 10)}$ or $\frac{(1 - 10)}{(1 - 10)} \; \square \; (1 - 5)$	$< \; = \; >$
15	$a = (1 - 10)$ $b = (1 - 10)$ $a \; \square \; b$	$< \; = \; >$

The scoring of Drill-4 will be by the same method used in Drill 1 and Drill-2, i.e., the student must answer 5 problems in succession correctly to move to a more difficult level. The score will drop to zero when one problem is missed. When two problems in succession are answered incorrectly the student will go back one level.

Proctor messages indicate whether the student has signed off or completed Drill-4. If he signs off the proctor message indicates this, gives the drill number (Drill-4) and his present level.

Fractions. Drill-5 contains exercises in reducing fractions to their lowest terms: adding, subtracting, multiplying and dividing fractions; changing mixed numbers to improper fractions: and multiplying whole numbers by fractions. The student must express all answers in least common terms.

The program contains fifteen levels. The student signs on at the lowest level and continues until he completes all levels or until he signs off. As before, the student must answer correctly 5 problems in succession to go to the next higher level. If he answers 2 problems in a row incorrectly he will go back to the next lower level.

Proctor messages will tell if the student signs off or if he completes all levels in Drill-5. If the student signs off before completing Drill-5 the proctor message will indicate the name of the drill (fractions), the number of the drill (Drill-5), and his present level.

APPENDIX E

ALGEBRA OFF-LINE PROGRAM

Algebra Off-Line Program

Purpose

The purpose of the off-line program is to better meet the learning needs of each student in the Consortium CAI Algeb and Genma courses. The off-line program should:

1. Provide some remedial help for students who are having difficulty with the on-line program. This will be a more critical problem as the pupil/teacher ratio in the classroom increases.

2. Allow the better students to progress through the course more rapidly. This might be accomplished by the study off-line of some topics which occur on-line later in the course. The possibility of studying later topics earlier is evidenced by the different order in which textbook authors present various topics.

3. Provide the opportunity for some students to look at some topics in greater depth. For example, the study of many of the properties of equality, multiplication, addition, etc., seems trivial to students when applied to sets of whole numbers, integers and real numbers. Sometimes they develop a better understanding of these properties by examining systems which do not have these properties.

4. Promote the students' enjoyment of and appreciation for the study of mathematics. In recent years some excellent material has been developed to introduce such topics as probability, matrices, topology, number theory and others to high school students on a level which they can readily comprehend. Many of these presentations are intriguing and novel. For the student who has been working hard week after week with the on-line program, a short look at these could be a refreshing change.

5. Provide a readily available, useful activity for any time the student could not go ahead on his regular work. This might occur if he has difficulty at a time when the teacher is busy or if he is ready to go on line and a terminal is not available.

Types of off-line material (Algeb)

The off-line material can be separated into two basic categories: remedial work for those having difficulty and extra work for those progressing without difficulty.

There are three sources of help in the remedial area: the SRA Algebra Skills Kit, the Hayes ditto material, and the series of programed texts, A Program in Contemporary Algebra. The two former sources are mainly for additional practice. These resources will be correlated with the on-line material by chapter and block.

The extra work can be classified as additional topics (AT), in depth (ID), acceleration (LA), and games and puzzles (GP). Most of this material is in the form of pamphlets or work books. Some of the suggested activities are small "experiments" or games. The programed text will be used for acceleration activities as well as remedial. By studying some topics off-line, the student may be able to pass the pretest on the topic and thus move ahead on-line to new materials.

Filing off-line activity assignments

The remedial activities which are correlated directly with the on-line material will be listed on assignment sheets to be kept in a notebook. The assignments will be made by the on-line program if a student misses an out quiz two times.

The extra activities are written on 5 x 8 cards which will be filed. Each card contains the source of the activity (booklet name, etc.), a sentence or two describing the activity, and chapter or page references (where appropriate). In addition, in the upper right hand corner of the card is a code to indicate the nature of the activity (AT, ID, LA, or GP), the chapter which should be completed before the activity is attempted (if there is a prerequisite), and a reading level coded *, **, ***, (***being the most difficult level of reading).

Implementing the off-line program (General)

In order for the off-line program to work efficiently, the student must be instructed in its usage early in the school year. If he knows what is available and where it is located he should be able to proceed on his own when the teacher is working with other students. These activities are not meant to replace individual student/teacher interaction but to conserve on teacher resources.

When a student fails an out quiz, he is presented with four options: instruction, practice, summary, or off. For some it will be sufficient to simply repeat one, or part of one, of the first three choices. Other students may opt to repeat the entire instructional block.

If this review work is not adequate, the student may choose to sign off and see the teacher with questions or look in his notebook for remedial work. More practice with the Skills Kit, or additional explanations in the programed text may be sufficient to solve his problem. This provides the student with a useful instructional activity at times when several other students may be waiting to see the teacher.

At other times, students may be signed off to do an assignment and may not be able to sign on again when the assignment is completed because all the terminals are in use. In order not to waste time, he could choose an activity from the card file which would allow him to move ahead faster, to look at a topic in depth, etc.

There may also be times when the fastest students are ahead of schedule and would like, for a change, to look at some of the additional topics off-line: he could work on this for one or more periods and then return to his on-line work. (These additional topic activities will be used only in the latter part of the year when the student is sufficiently far along that we can be assured that he will cover the necessary material.)

In order for this program to be effective, there are several prerequisites.

Since this type of activity may be new to the students, they will need to have it explained to them carefully and be closely supervised at the start of the school year. They must understand that this is an important, integral part of the program, not just an added frill.

The package of off-line material which has been developed thus far is only a start. Many other excellent sources are available and can be added because of the flexibility of the card file. Filmstrips are one of the possible additions. It is hoped that the teachers will make suggestions for additional materials as useful activities are discovered in the classroom.

APPENDIX F

LIST OF COMMERCIAL
OFF-LINE CURRICULUM MATERIALS

RECOMMENDED OFF-LINE CURRICULUM MATERIALS

Printed Materials

Item	Source
A Collection of Cross Number Puzzles	J. Weston Walch
Algebra (dittos)	Hayes School Publishing Co., Inc.
Algebra A Modern Approach, 2nd. Ed.	D. VanNostrand Corp.
Algebra Can Be Fun	J. Weston Walch
Algebra Skills Kit	Science Research Associates, Inc.
Amusements in Mathematics	LaPine Scientific
Common Fractions	Lafayette Parish Schools
Conversion of Measures	Lafayette Parish Schools
Decimal Fractions	Lafayette Parish Schools
Discovery and Structure Series	Addison-Wesley Publishing Co.
Enlarging Math Ideas	Ginn and Company
Essentials of Math, Skills and Concepts	Ginn and Company
Eureka Booklet	Creative Publications
Experiences in Mathematics Discovery Booklets 1, 2, 3, 5	National Council of Teachers of Mathematics
Experiments in Mathematics Stage 1, 2, 3	Houghton Mifflin Co.
Exploring Math Ideas	Ginn and Company
Extending Math Ideas	Ginn and Company
Exploring Mathematics on your Own (series) Topology, Finite Mathematical Systems, Adventures in Graphing, Number Patterns, Basic Concepts of Vectors, The World of Measurement, The World of Statistics, Probability and Chance, Logic and Reasoning in Mathematics	Webster Publishing Co.
Fantasia Mathematics	LaPine Scientific
From Zero to Infinity	LaPine Scientific
Fun with Mathematics	LaPine Scientific
Games for Learning Math	J. Weston Walch
Geoboard Geometry	Cuisenaire Company
Geometry Can Be Fun	J. Weston Walch
Getting a Line on Math	Cuisenaire Company
Graphing Math Sentences	Ginn and Company
How Children Fail	Cuisenaire Company
How Children Learn	Cuisenaire Company
How to Teach Math in Secondary Schools	Saunders Teaching Series
Informal Geometry	Lafayette Parish Schools
Introduction to Algebra	Lafayette Parish Schools
Introduction to Math Sentences	Ginn and Company
Introduction to Optical Illusions	J. Weston Walch

Item	Source
Laboratory Manual for Elementary Mathematics	Prindle, Weber and Schmidt, Inc.
LAMP (Low Achiever Motivational Project)	Des Moines Public Schools
Let's Go Out to Eat	Lafayette Parish Schools
Math Photo Quiz	J. Weston Walch
Math Puzzles and Pastimes	LaPine Scientific
Math-with Numbers in Color "A" & "B"	Cuisenaire Company
Mathematical Bingo	J. Weston Walch
Mathematical Puzzles	LaPine Scientific
Mathematics Classroom Library	Charles E. Merrill Co.
Mathematics Illustrated Dictionary	Cuisenaire Company
Mathematics, Its Content, Method, Meaning	American Math Society
Mathematics: Man's Key to Progress Book A, B	Franklin Publishers, Inc.
Matrices 1	Houghton Mifflin Company
Measures of Central Tendency	Educational System Development
Measures of Dispersion	Educational System Development
Men of Mathematics	LaPine Scientific
Mits, Wits, and Logic	LaPine Scientific
Modern Mathematics (dittos) Grade 7, Book 1, 2 Grade 8, Book 1, 2 Grade 9, Book 1, 2	Hayes School Publishing Co., Inc.
Notes on Geoboards	Cuisenaire Company
Number Principles and Patterns	Ginn and Company
Number Sentences	Lafayette Parish Schools
100 Mathematical Curiosities	J. Weston Walch
Operations with Whole Numbers	Lafayette Parish Schools
Opportunities in Mathematics	J. Weston Walch
Optical Illusions	J. Weston Walch
Other Bases in Arithmetic	Ginn and Company
Patterns and Discovery Series	Addison-Wesley Publishing Co.
Patterns and Puzzles in Mathematics	Franklin Publishers, Inc.
Per Cent	Lafayette Parish Schools
Presentation of Data	Educational System Development
Probability and Statistics	Charles E. Merrill Company
Program for Mathematically Underdeveloped Pupils	Palm Beach County, Florida
A Program in Contemporary Algebra, Revised Edition, Books 1-5	Holt, Rinehart, and Winston
Ratio and Proportion	Lafayette Parish Schools
Riddles in Mathematics	LaPine Scientific
Self Teaching Arithmetic	Scholastic Books
Sets in Geometry	Ginn and Company
Skills and Patterns Series	Addison-Wesley Publishing Co.
Survey Test of Algebraic Aptitude	California Test Bureau
30 Projects for Math Clubs	J. Weston Walch
The Education of T. C. Mits	LaPine Scientific
The Great Mathematicians	LaPine Scientific

Item	Source
The Math Wizard	J. Weston Walch
What is Modern Math?	J. Weston Walch
Whole Numbers--Factors	Lafayette Parish Schools
Worksheet Pads--40 exercises	Cuisenaire Company
Yes, Mathematics Can Be Fun!	J. Weston Walch

OFF-LINE CURRICULUM MATERIALS

Manipulative Materials

Item	Source
Celluloid pocket rules	LaPine Scinetific
Centimeter Decimal Set and Strip	H & M Associates
Checkline	Creative Publications
Counting Frame	Kurtz Brothers
Cuisenaire rods	Cuisenaire Company
Cyclo Teacher	Field Educational Publications
Decimal Fraction Dominoes	Responsive Environments Corp.
Equations	Wff'n Proof
Fraction Dominoes	Responsive Environments Corp.
Geoboard	Cuisenaire Company
Heads Up	E. S. Iowe
Kalah	Creative Publications
Kount-N-Kube	Creative Publications
Lego (gears 001)	Learning Materials Division
Nice Cubes	Cuisenaire Company
Numble	Selchow & Righter Company
ON·SETS	Wff'n Proof
Plastic Mathematical Balance	H & M Associates
Psychepaths	Cuisenaire Company
REAL numbers game	Wff'n Proof
Sage Kit	LaPine Scientific
Space Spiders	LaPine Scientific
Tac-Tickle	Wff'n Proof
Tri Nim	E. S. Iowe
Tuf	Cuisenaire Company
WFF	Wff'n Proof
Wff'n Proof	Cuisenaire Company

OFF-LINE CURRICULUM MATERIALS

Filmstrips

Item	Source
Addition and Subtraction of Decimals	Educational Projection Corporation
Bar Graphs Comparison	Educational Projection Corporation
Building Concepts in Math	Imperial Film Company
Circle Graphs Relationships	Educational Projection Corporation
Comparing Fractions	Educational Projection Corporation
Discovering Solids w/records	Imperial Film Company
Division of Decimals	Educational Projection Corporation
Expressing Common Fractions	Educational Projection Corporation
Formulas and Functions	Popular Science
Inequalities	Popular Science
Introducing Decimal Notations	Educational Projection Corporation
Introducing Percent	Educational Projection Corporation
Introduction to Graphs	Educational Projection Corporation
Line Graphs-Trends	Educational Projection Corporation
Measurement of Angles and Arcs	Popular Science
More Problems in Percent	Educational Projection Corporation
Multiplication of Decimals	Educational Projection Corporation
Operations: Polynomials & Fractions	Popular Science
Parallel Lines and Parallelograms	Popular Science
Picture Graphs Counting	Educational Projection Corporation
Postulates in Algebra	Popular Science
Problem Solving I	Popular Science
Problem Solving II	Popular Science
Series	Popular Science
Signed Numbers	Popular Science
Solving Equations	Popular Science
Solving Problems in Percent	Educational Projection Corporation
Studying Triangles	Popular Science
Two Linear Equations	Popular Science
Miscellaneous	Popular Science
An Introduction to Coordinate Geometry	
An Introduction to Probability	
How a Computer Solves a Problem	
Indirect Measurement Tangent Ratio	
Introduction to Irrational Numbers	
Mean Proportion and Right Triangles	
Nature of Roots of Quadratic Equations	
Points, Lines and Planes	
Rearrangement Theorem of Addition	
Sum of the Measures of Angles of a Triangle	
The Slope of a Line	
Truth Tables	

APPENDIX G

COURSE CONTENT

ALGEB

Chapter 1 — Number and Set Notations

A. Sets

1. Intuitive definition of set
2. Examples of sets
3. Definition of elements of a set
4. Braces used to designate a set
5. Constructing a roster from a rule
6. Recognizing a rule for a roster
7. Definition and recognition of a null set
8. Symbols for the null set, that is { } and $\emptyset$
9. Symbols for "is an element of" (that is, $\in$) and "is not an element of" (that is, $\notin$)
10. Recognizing a well-defined set (optional)

B. Subsets

1. Definition and examples
2. Definition and examples of proper subset
3. Use of symbol for "is a subset of" (that is, $\subset$)
4. Definition and examples of equal sets
5. Classification of sets as finite and infinite

C. Intersection and Union of Sets

1. Definition and examples of the intersection of two sets
2. Symbol for intersection
3. Definition and examples of the union of two sets
4. Symbol for union
5. Disjoint Sets (optional)

D. Order of Operation

1. Presentation of the following as the accepted order:
   a. Work in parentheses
   b. Multiply or divide from left to right
   c. Add or subtract from left to right

2. Problems involving two or more operations

E. Inequalities

1. Reading of symbols listed below
2. Using symbols listed in number sentences
   Symbols: $=$, $>$, $<$, $\leq$, $\geq$

F. Exponents

1. Use of the word "factor"
2. Writing expressions with repeated factors using exponents
3. Writing expressions with exponents using repeated factors
4. Writing exponential expressions for verbal phrases
5. Use of raised dot to indicate multiplication
6. Simplifying a numerical expression containing exponents
7. Evaluating exponential expressions for given values of the variables

G. Open Sentences

1. Definition and recognition of variables in expressions
2. Definition and recognition of an open sentence
3. Definition of domain and solution set
4. Finding a solution given domain and open sentences.
5. Changing easy word sentences into algebraic symbols

H. Graphing on the Number Line

1. Marking off units on the non-negative number line
2. Giving names for the units
3. Use of the word, "coordinate"
4. Graphs as a way to specify sets
   a. Given a set, show the graph
   b. Given a graph, indicate the set
5. Set builder notation

ALGEB

Chapter II

Properties of Equality and Operations

A. Equality Relations

1. Reflexive property: a = a
2. Symmetric property: If a = b, then b = a
3. Transitive property: If a = b, and b = c, then a = c

B. Closure Property

1. Non-verbal introduction
2. Example of closed sets
3. Example of sets that are not closed

C. Commutative Property

1. Commutative properties of addition and of multiplication
2. Does commutative property hold for division and for subtraction
3. Choose the operations that are commutative

D. Associative Property

1. Idea of a binary operation
2. Regrouping numbers
3. Associative properties of addition and of multiplication
4. Drill on associative property

E. Distributive Property

1. Example using ticket sales
2. Substitute variables for numbers
3. Definition of distributive property of multiplication with respect to addition
4. Distributive property for more than three numbers
5. Distributive property of multiplication with respect to subtraction
6. Drill on distributive property

F. Properties of Zero and One

1. The addition property of zero: a + 0 = a
2. The multiplication property of zero: a · 0 = 0
3. The multiplication property of one: a · 1 = a

G. Recognizing Properties

1. Given property, identify example
2. Given example, identify property
3. True-false: statement of properties

ALGEB

Chapter III

Integers: Properties and Operations

A. Integers on the Number Line

1. Integers to the left of 0
2. Integers which are opposite
3. Positive and negative integers
4. 0, neither positive nor negative
5. Designative the set of integers
6. Indicating subsets of integers
7. Indicating graphs of subsets of integers
8. Indicating the set of integers shown on a graph

B. Order in the Integers

1. Ordering of integers on the number line
2. Ordering of given sets of listed integers
3. Transitive property of inequality
4. Comparison property

C. Absolute Value of Integers

1. Removing absolute value symbols
2. Definition of absolute value
3. Simplifying numerical expressions containing absolute value symbols
4. Solving equations containing absolute value symbols
5. Graphing solution sets for open sentences containing absolute value symbols

D. Adding Integers

1. Addition on a thermometer
2. Addition on the number line
3. Rules for adding integers
4. Practice adding 2 integers horizontally
5. Practice adding 3 or more integers horizontally
6. Practice adding 3 or more integers vertically

E. Addition Properties of Integers

1. Closure
2. Commutative property
3. Associative property
4. Addition of 0
5. Addition property of opposites
6. Opposite of sum

ALGEB

Chapter III

Integers:
Properties and Operations

F. Multiplying Integers

1. Multiplication of a positive integer by an integer as a repeated addition
2. Guided discovery of rule of signs for multiplication of a negative integer by an integer
3. Practice on multiplying 2 or more integers
4. Rule of signs for multiplying more than 2 integers
5. Evaluating variable expressions for given values of the variable (optional)

G. Multiplication Properties of Integers

1. Closure
2. Commutative property
3. Associative property
4. Multiplication property of 0
5. Multiplication property of 1
6. Finding the product of several terms

H. Distributive Property

1. Expressing the indicated product as an indicated sum
2. Expressing the indicated sum as an indicated product

I. Subtracting Integers

1. Intuitive approach to subtraction as addition of the opposite
2. Subtraction of integers horizontally
3. Subtraction of integers vertically
4. Solution of sentences of the form

   $x + a = b$, when a and b are integers

J. Combining Like Terms

1. Definition of: term, like terms, unlike terms
2. Simplifying expressions containing like terms

K. Dividing Integers

1. Intuitive approach to rule of signs for division
2. Division of integers giving an integral result
3. Definition of rational number
4. Solution of sentences of the form $ax = b$ when a and b are integers
5. Substituting values and simplifying indicated quotients

ALGEB

Chapter IV

Operations with Rational Numbers and Real Numbers

A. Rational Numbers

1. Introduction: Integers closed under +, -, and ·, but not closed under ÷
2. Definition of a rational number
3. Integers expressed as rational numbers

B. The Density Property

1. How to type fractions on the CRT
2. Extension of the number line to include rational numbers
3. Showing by successive bisections that between any two points on the number line, there is another rational number
4. Definition of density property

C. Equivalent Frantions, formed

1. By multiplying numerator and denominator by the same number
2. By dividing numerator and denominator by the same number

D. Comparing Rational Numbers

1. Rule for comparing rational numbers with like denominators
2. Using equivalent fractions to order two fractions
3. Ordering fractions using <, =, >

E. Properties of Rational Numbers

1. Commutative property of addition
2. Associative property of multiplication
3. Associative property of addition
4. Commutative property of multiplication
5. Distributive property

F. Reciprocals

1. Additive inverse
2. Definition of reciprocal
3. Finding reciprocal of rational numbers and rational expressions
4. Zero has no reciprocal

G. Real Numbers

1. Review of changing fractions to a decimal
2. Terminating, non-terminating, and repeating decimals
3. Definition of set of
   a. Irrational numbers
   b. Real numbers
4. Property of completeness
5. Graphing on the real number line.

ALGEB

Chapter IV

Operations with Rational Numbers and Real Numbers

H. Prime Factorization and Least Common Multiple (LCM)

1. Finding the set of factors of a number
2. Prime numbers
3. Review of how to type multiplication dot
4. Process of finding the prime factorization
5. Prime factorization of algebraic expressions
6. Finding the LCM
7. Relation between LCM and LCD

I. Reducing Fractions

1. Review of reducing fractions
2. Reducing rational expressions
3. Review of equivalent negative fractions

J. Multiplication of Fractions

1. Multiplication of fractions
2. Multiplication of rational expressions

K. Division of Fractions

1. Review of
   a. Multiplication of fractions
   b. Division
   c. Reciprocals
2. Division using concepts of multiplication and reciprocals

L. Addition and Subtraction of Fractions with Like Denominators

1. Adding fractions using the distributive property
2. Rule for adding fractions
3. Subtracting fractions using the distributive property
4. Rule for subtracting fractions

M. Adding Fractions with Unlike Denominators

1. Review of adding fractions
2. Adding rational expressions
   a. Finding LCD
   b. Forming equivalent fractions
   c. Using distributive property to add numerators
   d. Placing sum of numerators over LCD

ALGEB

Chapter V

Equations, Inequalities and Problem Solving

A. Open Phrases

1. Definition of an open phrase
2. Recognizing the English equivalent of an open phrase
3. Writing open phrases for English phrases in the following types of problems:
    a. Value
    b. Consecutive integers
    c. Distance

B. Open Sentences

1. Open and closed mathematical sentences
2. Examples of practical (real world) problems

C. Solution Sets

1. Definition of solution set, root, simple equation
2. Solving equations with a restricted replacement set
3. Definition of identity
4. Solving inequalities with restricted replacement sets
5. Solving open sentences (domain = real numbers)
    a. Addition property of equality
    b. Finding an additive inverse
    c. Multiplication property of equality
    d. Equivalent equations
    e. Solving equations using additive inverses
    f. Solving equations with variables on both sides of the equation
    g. Solving equations using multiplicative inverses
    h. Solving equations using both inverses

D. Verbal Problems

1. Recognizing an operation from its English equivalent
2. Simple word problems
3. Appollo rocket problem
4. More word problems (number, value, consecutive integer, age, distance)

E. Formulas

1. Writing a formula to express a rule
2. Using formulas to solve problems
3. Changing the subject of a formula
    a. Comparison of steps used to those used for solving equations in one variable
4. Review of inverse operations
5. Solving equations in several variables for one of the variables (in terms of the others)

ALGEB

Chapter V

Equations, Inequalities and Problem Solving

F. Inequalities

1. Properties of "is greater than"
   a. Transitive
   b. Addition
   c. Multiplication
2. Solving inequalities
   a. Graph of solutions sets of inequalities
   b. Simplifying inequalities

ALGEB

Chapter VI

Linear Systems

A. The Real Number Plane

1. Ordered pairs of real numbers associated with points
2. Reading ordered pairs and naming points using ordered pairs
3. Terms: X-axis, Y-axis, origin, abacissa, ordinate
4. Properties of quadrants
5. Points on an axis and the origin
6. Plotting points, given ordered pairs

B. Graphs of Linear Systems

1. Linear equations in two variables

   ($Ax + By + C = 0$, where A and B are not both 0)

2. Solution set for an equation in two variables
3. Graph of solution set
   a. Lines parallel to an axis
   b. Lines in general
4. Equivalent equations

C. The Slope-Intercept Form

1. y-form: $y = mx + b$
2. slope $= \frac{\text{change in vertical distance}}{\text{change in horizontal distance}}$
3. Finding slope
   a. Given two points
   b. Given equation
4. Graphing linear equations
5. Parallel lines

D. Writing Equations for Lines, when given

1. Slope and y-intercept
2. Two points
3. One point and parallel line
4. One point and y-intercept
5. Slope and x-intercept
6. x-intercept and y-intercept

E. Systems of Linear Equations

1. Compound sentences using connective "or"
   a. Conditions for the sentence being true
   b. Solution set
   c. Graph
2. Compound sentences using connective "and"
   a. Conditions for the sentence being true
   b. Solution set
3. System of equations
   a. Solution set
   b. Consistent and inconsistent systems

F. Solving Systems of Equations

1. Equivalent systems
2. Elimination method
   a. Adding or subtracting
   b. Multiplication required
3. Substitution method

G. Solving Verbal Problems

1. "number" problems
2. "age" problems
3. "rate" problems

ALGEB

Chapter VII

Polynomials

A. Powers

1. Definition and examples
2. Exponential and expanded form
3. Multiplication of powers
4. Division of powers
5. Raising a power to a power
6. Zero as an exponent
7. Negative exponents (optional)

B. Polynomials in one variable

1. Inductive development of definition of a term
2. Formal definition of a term
3. Using terms as building blocks to construct polynomials
4. Definition of polynomials
5. Types of polynomials
6. Ordering polynomials (ascending, descending)
7. Degrees of a polynomial in one variable

C. Operations with Polynomials

1. Addition of polynomials
2. Subtraction of polynomials
   a. Finding the opposite of a polynomial
3. Multiplication of polynomials
   a. Multiplication product compared to the area of a rectangle
4. Division of polynomials
   a. Division by a monomial
   b. Division by a polynomial

ALGEB

Chapter VIII Factoring Polynomials

A. Common Monomial Factors

1. Finding the greatest common factor
2. Factoring out common factors
3. Polynomial products compared to the area of a rectangle

B. Special Products and Factoring

1. Squaring binomials
   a. Perfect square trinomial pattern
   b. Short cut for squaring a binomial
2. Multiplying the sum and difference of two quantities
   a. Product pattern
3. Factoring perfect square trinomials
   a. Recognizing a perfect square trinomial
4. Factoring the difference of two squares
   a. Recognizing a difference of two squares
5. Multiplying binomials by sight

C. Factoring Quadratic Trinomials

1. Trinomials of the form $ax^2 + bx + c$ $(a = 1)$
   a. Factoring clues: signs and coefficients
   b. Terms of a quadratic trinomial
   c. Random drill on factoring
2. Trinomials of the form $ax^2 + bx + c$ $(a \neq 1)$
   a. Trial and error approach
   b. Factoring by rewriting the trinomial as a polynomial of four terms

D. Factoring Completely

1. Reducible and prime polynomials, definition and recognition

E. Solving Quadratic Equations

1. Factors whose product is zero
2. Steps for solving quadratic equations

CAI COURSE CONTENT

GENMA

Chapter	Topic
I	Equations
II	Negative Integers
III	Division of Whole Numbers
IV	Decimals
V	Fractions
VI	Ratio and Proportion
VII	Percent
VIII	Formulas
IX	Geometry
X	Measurements
XI	Graphing

GENMA

Chapter I — Equations

A. Number Sentences

1. True
2. False
3. Open
   a. Given the selector set choose the solution
   b. Construct an open sentence given the "parts"
   c. Find the solution for open sentences

B. Equations

1. True equations
2. Solution from a selector set
3. Find the solution of
4. To solve

C. Equivalent Equations of the Form $n + a = b$, $b > a$
$n = b - a$

1. Generalization (subtract same number from both sides)
2. Variable in either member
3. Equations with 3 terms in one member
   i.e., $a + b + n = c$, such that $a, b > o$ $c > a + b$

D. Equivalent Equations of the Form $n - a = b$ $a > o$, $b > a$

1. Generalization (add the same number to both sides)
2. Variable in either member
3. Equations with as many as 4 terms in one member with the coefficient of the variable understood as 1. The operations between the constants are either + or - and the sums, differences, and solutions are always positive integers.

E. Equivalent Equations of the Form $ax = b$ where $a, b \in N$, implies _a_ divides _b_.

1. Generalization (divide both sides by the same natural number)
2. Solve more using the generalization

F. Solving Equations of the Form $\frac{1}{a} n = b$, $a, b \in N$

1. Given the selector set
2. Use equivalent equations to solve (generalization)
3. Solve more of same using equivalent equation

G. Solving Equations of the Form $\frac{a}{b} n = c$, $a, b, c \in N$, implies _a_ divides _bc_

1. Use above generalization to solve
2. Drill on multiplicative inverses

GENMA

Chapter II — Negative Integers

A. Number Line

1. "Up and back" language using arrows
2. Negative and positive numbers on the number line
3. Multiples of 10 between $[-40, 40]$
4. Removal of number line as "crutch"

B. Shortened Notation - Mathematical Symbols

1. Start in positive region
2. Start in negative region
3. Calculating sums and differences of signed numbers whose absolute value < 100

C. Solving Equations with Negative Integers

1. Refresher of previous generalization (subtract from both sides)
2. Solving equations whose solution is > -50, and < 50
3. Solving equations with negative and positive solutions using numbers of larger absolute value

D. Solving Equations by Addition

1. Adding the same variable to both sides
   i.e., $a - n = b$ vs $n - c = d$

E. Football Game--Positive and Negative Numbers

1. Drill in adding signed numbers
   a. Given addends alike so that better students might intuitively "see" multiplication

F. Multiplying Positive and Negative Integers

1. Using vectors to show like addends with ultimate discovery being short-cut of adding
2. Finding products of signed numbers using parentheses to indicate multiplication

GENMA

Chapter III

Division of Whole Numbers

A. Methods

1. Repeated subtraction
2. Common division algorithm

GENMA

Chapter IV

Decimals

A. Introduction of Place Value

1. Use of abacus to show place value
2. Reading and writing place value; reference to abacus.

B. Comparison of Decimals

1. Equivalent decimals
2. Finding the largest decimal of a group
3. Remedial work using abacus

C. Rounding of Decimals

D. Placing Decimals in Value Order

E. Adding Decimals

F. Subtracting Decimals

1. Using abacus
2. Inventory

G. Multiplying and Dividing Decimals

1. Remedial work
2. Achievement tests

H. Verbal Problems with Decimals

1. Emphasizing equations
2. 1st stage (addition and subtraction)
3. 2nd stage (multiplication and division)
3. 3rd stage (combination of 1st and 2nd stages)

GENMA

Chapter V Fractions

A. Equivalent Fractions

1. Geometric representation
2. As parts of a given set
3. Given five elements in a set of equivalent fractions, type the next three elements
4. Using the property of 1 to relate equivalent fractions
5. Use of the lowest terms fraction to name the set
6. Give the lowest terms equivalent fraction for a given fraction
7. Location of points on the number line that name an infinite set of equivalent fractions

B. Number Line

1. Given the whole number scale on top the student labels the number line by halves, thirds, fourths, eights, etc.
2. Type the fraction for various points given on the scale
3. Whole numbers written as rational fractions with different denominators

C. Adding and Subtracting Fractions

1. Adding like fractions on number line (equation context)
2. Subtracting like fractions on number line (equation content)
3. Finding sums and differences of unlike fractions using equivalent fractions

D. Mixed Numbers

1. Solving equations by multiplication
2. Solving equations by division
3. Improper fractions

E. Common Fractions and Decimals

1. Fractions to decimals
2. Decimals to fractions

GENMA

Chapter VI

Ratio and Proportion

A. Establishing Comparisons Between Two Quantities

1. Definition of ratio as a comparison
2. Comparing numbers of objects, using displays
3. Comparing lengths of line segments

B. Expressing Ratios as Fractions

C. Using Ratios to Express Rates

D. Definition of Equivalent Ratios

1. Associate correct display with given ratio
2. Demonstration of "property of one" to write equivalent ratios

E. Definition of Proportion

1. Testing for proportions, using cross products
2. Solving proportions for the unknown term
3. Verbal problems involving proportions

GENMA

Chapter VII Percent

A. Percent, Fractions, and Decimals

1. Writing percent as a fraction (hundredths)
2. Writing percent as a decimal (hundredths)
3. Writing fractions as decimals, percents, ratios

B. Verbal Percent Problems

1. Percent and fractional equivalents
2. Using equations to solve percent problems
   a. Interest
   b. Discount

GENMA

Chapter VIII Formulas

A. Evaluation Expressions

1. Using of displays for counting
2. Substituting fixed values in variable expressions
   a. Simple single variable expressions
   b. Variable expressions with coefficients and order of operations

B. Developing Formulas by Induction

1. Inductively arrive at a formula given data on the variables
2. Given data for two variables, solve a formula for remaining variables
3. Evaluating formulas, arranging data in tabular form
4. Writing formulas from data given in tabular form
5. Evaluating formulas with second degree terms and factors

GENMA

Chapter IX   Geometry

A. Space Figures

1. Introduction
2. Defining and identifying faces, vertices, edges
3. Constructing three space figures
   a. Tetrahedron
   b. Pentagonal Prism
   c. Square Pyramid
4. Compiling data from models
   a. Counting faces, edges, vertices
5. Development of Euler's Formula

B. Plane Figures

1. Defining and identifying regions (closed areas), meets (vertices) and paths (side segments)
2. Developing and applying a form of Euler's Formula for plane figures
3. Properties of plane figures
   a. Inside - outside
   b. Open - closed
   c. Convex - not convex

C. Linear Figures

1. Defining line, line segment, ray
2. Property of being infinite

D. Recognizing Figures as Linear, Plane or Space

E. Angles

1. Naming
2. Measuring
3. Drawing
4. Comparing
5. Grouping
   a. Acute
   b. Right
   c. Obtuse

F. Perpendicular and Parallel Lines

G. Triangles

1. Grouping
   a. Right, obtuse, acute
   b. Equilateral, isosceles, scalene
2. Sum of the angles
3. Altitudes

GENMA

Chapter IX

Geometry

H. Polygons

1. Quadrilaterals
   a. Square
   b. Rectangle
   c. Parallelogram
   d. Trapezoid
2. Pentagon
3. Hexagon

I. Constructions with Compass and Straight Edge

1. Review of circle and arcs for work with compass
2. Copy a given angle
3. Construct a triangle given 3 sides
4. Construct the bisector of a given angle
5. Construct a triangle given 2 sides and the included angle
6. Designs

GENMA

Chapter X Measurement

A. Introduction to Measurement
   1. Types of measurement
   2. Everyday use of measurement
   3. Measuring devices and uses

B. Linear Measure
   1. Unit conversion
      a. Table of linear measures
      b. Equivalent linear measures
   2. Line segments
      a. Measuring
      b. Congruency
   3. Arithmetic operations
      a. Adding the measures of line segments for total length
      b. Converting measurements to
         — mixed units
         — decimal equivalents
         — fractional equivalents
      c. Verbal problems

C. Introduction to the Pythagorean Theorem

D. Area Measure
   1. Unit conversion
      a. Table of area measures
      b. Equivalent area measures
   2. Finding area
      a. Square regions
      b. Rectangular regions
   3. Total area
      a. Rectangular solids

E. Cubic Measures
   1. Table of cubic measures
   2. Equivalent cubic measures
   3. Finding volume of rectangular solids

F. Circles
   1. Circumference
   2. Area

G. Weights and Dry Measures
   1. Table of weights and dry measures
   2. Finding equivalent weight and dry measurements
   3. Verbal problems

GENMA

Chapter X

Measurement

H. Time Measure

1. Table of time measures
2. Finding equivalent time measurements
3. Arithmetic operations with time measurements
4. Finding time differences
5. Verbal problems

GENMA

Chapter XI   Graphing

A. Introduction to Graphs

1. Definition and use of a graph (to represent data)
2. Identifying types of graphs
   a. Picture graph
   b. Bar graph
   c. Line graph
   d. Circle graph

B. Picture Graphs

1. Use of picture graph to introduce parts of a graph
   a. Title
   b. Legend
   c. Scale as a ratio
2. Reading a picture graph having a 1:1 scale
   a. Comparison of data by noting length of row
   b. Reading data by counting symbols
3. Reading a picture graph not having 1:1 scale
   a. Using ratios to condense data
   b. Given a ratio, determine number of symbols needed to represent data and vice-versa
   c. Comparison of data
   d. Using the scale to interpret data

C. Bar Graphs

1. Introduction to parts
   a. Horizontal scale and units
   b. Vertical scale and units
2. Reading a bar graph having a unit vertical scale
   a. Comparison of data
   b. Interpretation of data
3. Reading a bar graph having a vertical scale of multiple units
   a. Reading subdivisions of the vertical scale
   b. Comparison of data
   c. Interpretation of data

D. Line Graphs

1. Transition from bar to line graph
2. Discussion of vertical and horizontal scale and units
3. Reading line graphs
   a. Interpreting data
   b. Comparing data
   c. Noting trend

E. Circle Graph

1. Review of center and degrees (as percentage) of total circle
2. Use of parts of the circle to represent data
   a. Comparison of data by comparison of areas of circle
   b. Setting up proportions between fraction of data and fraction of circle
   c. Setting up proportions between percent of data and percent of circle
3. Reading a circle graph

F. Symbols of Value Order

1. $<, >, =$
2. Comparing values
3. Comparing numerical expressions
4. Value order with reference to position on number line

G. Addition Property of Inequality
Solving inequalities of the form

1. $n - a < b, \quad a > 0$
2. $n - a < b, \quad a < 0$

H. Multiplication Property of Inequality

1. Finding the solutions to open inequalities
2. Solving inequalities of the form
   a. $a \cdot n > b, \quad a > 0$
   b. $a \cdot n > b, \quad a < 0$

I. Solving Inequalities

1. Using both the addition and multiplication properties of inequality
2. Defining $\leq, \geq$
3. Given a selector set or a number line, choosing a solution set

J. Graphing Inequalities on a Number Line

K. Developing Two-Variable Equations

1. Recognizing patterns
2. Completing tables
3. Developing "rule" from table of two variables

GENMA

Chapter XI Graphing

L. Graphing Ordered Pairs

1. Definition of ordered pairs
2. Writing ordered pairs in the form (x,y) from tables of two variables
3. Introduction of horizontal and vertical axes
4. Plotting points
5. Naming the coordinates, given a point on the coordinate plane
6. Naming the point, given the coordinates on a coordinate plane

M. The Battleship Game

N. Multiplying Signed Numbers

1. Positive x positive = positive
2. Negative x positive = negative
3. Negative x negative = positive
4. Tabling values and plotting points for equations of the form
   a. $x = ay$ where $a = -1$
   b. $x = ay$ where $a < 0$

O. Graphing Linear Equations

1. Developing tables of ordered pairs from a linear equation
2. Recognizing the graph of a given equation
3. Recognizing the equation of a given graph

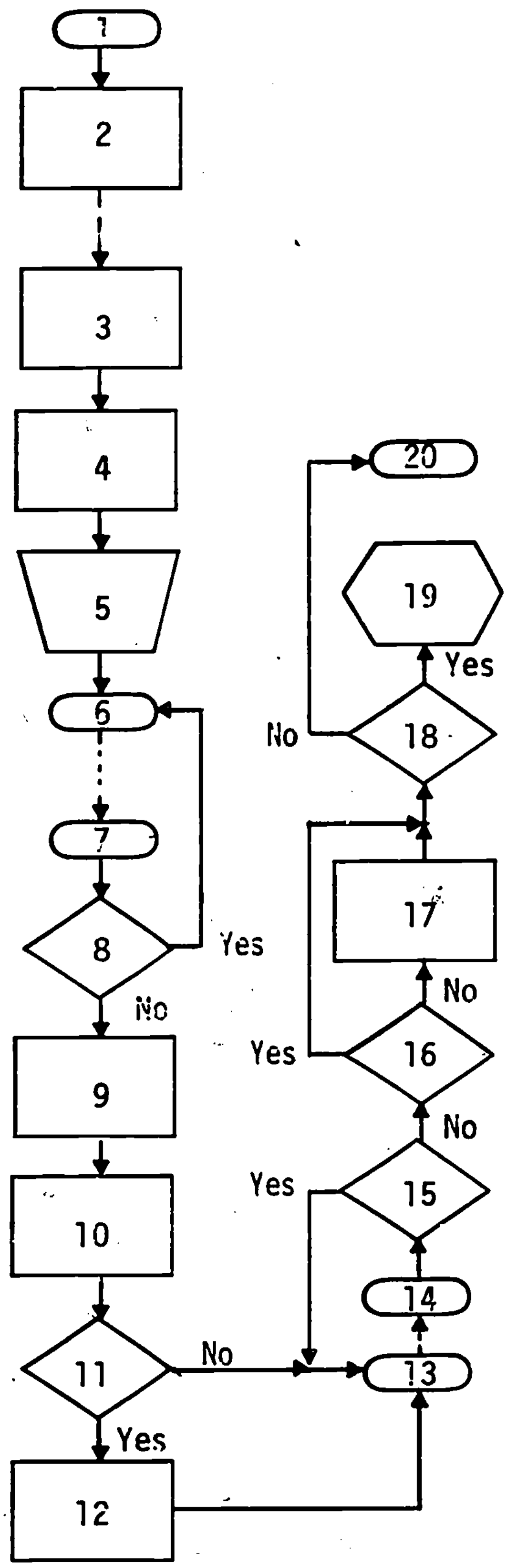
APPENDIX H

FLOWCHARTS

Key to Flowchart - Organization of a Chapter

1. From introduction to terminal procedures or from previous chapter.
2. Block 1.
3. Block n.
4. Chapter Review Test.
5. Student performance reported.
6. Signed off.
7. Signed on.
8. Chapter Review Test and Chapter Test the same day? If yes, go to 6. If no, go to 9.
9. Chapter Test.
10. Student performance reported.
11. Want review question same day as Chapter Test? If yes, go to 12. If no, go to 13.
12. Review questions of previous chapters.
13. Signed off.
14. Signed on.
15. Chapter Test and next chapter the same day? If yes, go to 13. If no, go to 16.
16. Review questions answered? If yes, go to 18. If no, go to 17.
17. Review questions on previous chapter.
18. Teacher option: Should student review portions of chapter? If yes, go to 19. If no, go to 20.
19. Skip routine to access blocks within chapter.
20. Next chapter.

ORGANIZATION OF A CHAPTER



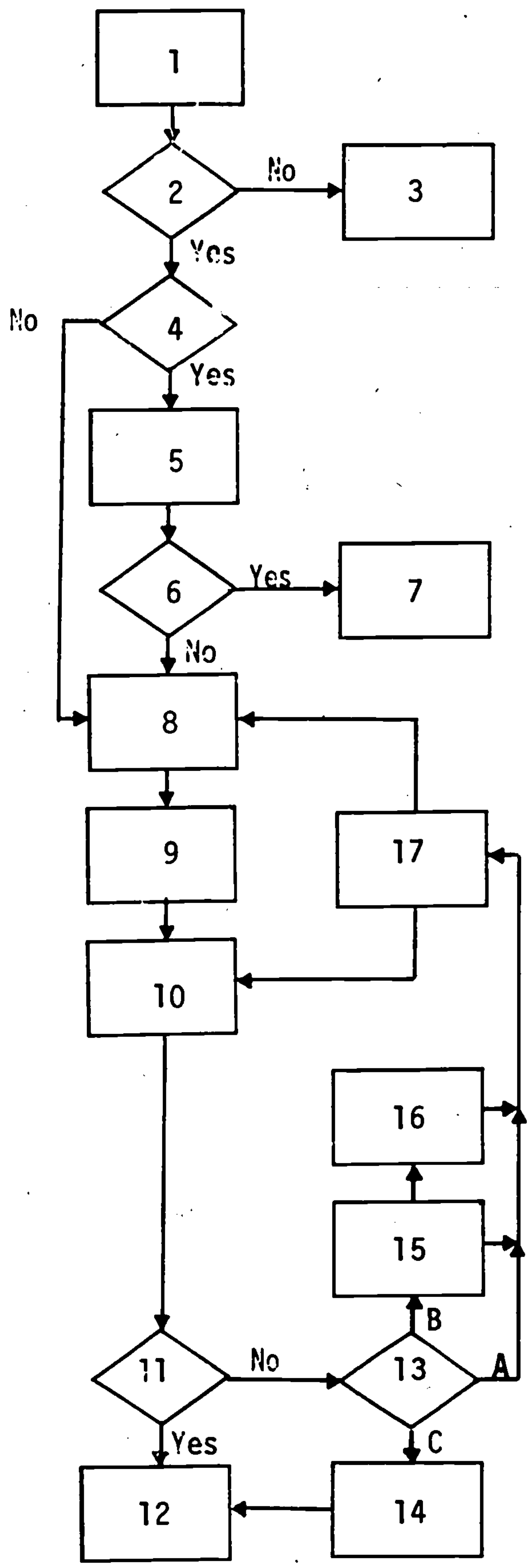
Key to Flowchart - Organization of an Instructional Block

1. Preskills test on block(s).*
2. Criterion met? If yes, go to 4. If no, go to 3.
3. Remedial and/or review.
4. Option to take pretest. If yes, go to 5. If no, go to 8.
5. Pretest on block(s).*
6. Criterion met? If yes, go to 7. If no, go to 8.
7. Next block not covered by pretest.
8. Instructional material (See Appendix E.3).
9. Off-line assignment mode.
10. Out-quiz on block(s).*
11. Criterion met? If yes, go to 12. If no, go to 13.
12. Next instructional block or chapter review test.
13. Number of iterations of out-quiz. If 1st iteration (A), go to 17. If 2nd iteration (B), go to 15. If 3rd iteration (C), go to 14.
14. Teacher informed of third failure of out-quiz. Go to 12.
15. Teacher informed. May assign additional off-line activity. If yes, go to 16. If no, go to 17.
16. Teacher assigns off-line material.
17. **Option routine. Go to 8 or 10. (Student's options)

---

*Any one or more of these may not exist for a given block.
**Only executed after first iteration of block.

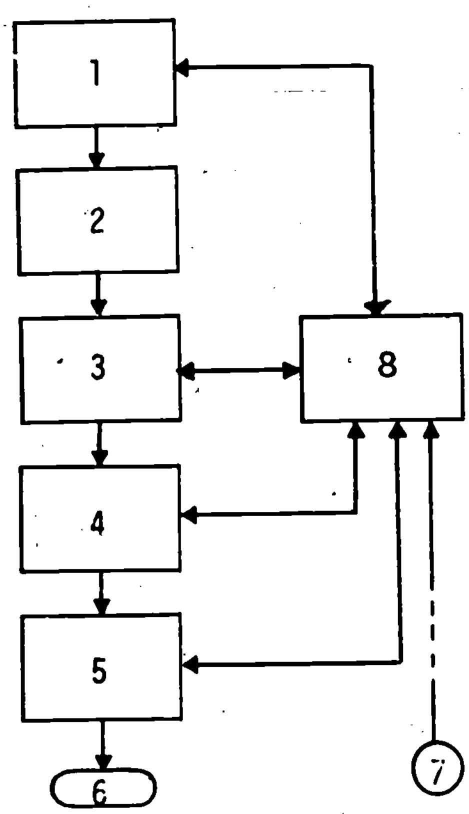
ORGANIZATION OF INSTRUCTIONAL BLOCK



Key to Flowchart - Instructional Material

1. Instruction frames. (Topic 1)
2. Assignment loaded.
3. Practice frames. (Topic 1)
4. Instruction and practice frames. (Topic 2)
5. Summary frames.
6. Sign off.
7. Failure to meet out-quiz criterion.
8. Options routine to access components of instructional material.

INSTRUCTIONAL MATERIAL



APPENDIX I

NON-NORMED ACHIEVEMENT TEST FOR GENERAL MATHEMATICS

TEST ON GENMA - FORM II

Lars C. Jansson

The Pennsylvania State University

Please do not write anything in this test booklet. This test contains 33 items and you have 40 minutes in which to complete it. All answers are to be marked on the separate answer sheets. Scratch paper is provided for any computation you need to do.

Do not begin until your teacher tells you to do so.

MARK YOUR ANSWERS ON THE SEPARATE ANSWER SHEET

1. Add the following: 17.43
   23.72

   a) .4115
   b) .3115
   c) 40.15
   d) 41.15

2. Choose the greatest number among those given below.

   a) 36.009
   b) 36.128
   c) 36.093
   d) 36.1128

3. Subtract: 10 - 5

   a) 50
   b) 5
   c) 2
   d) -5

4. Divide; $32\overline{)2016}$

   a) 125
   b) 66
   c) 63
   d) 62

5. 6 - 8 + 2 - 3 =

   a) 3
   b) 1
   c) 0
   d) -3

6. A positive number multiplied by a negative number gives

   a) a positive number
   b) a negative number
   c) a positive or negative number
   d) cannot tell

7. Fill in the box: 5 x □ = 15

   a) 3
   b) 2
   c) 1
   d) none of these

8. Fill in the box: □ - 2 = 8

   a) 16
   b) 10
   c) 6
   d) 4

GO ON TO THE NEXT PAGE

MARK YOUR ANSWERS ON THE SEPARATE ANSWER SHEET

9. Subtract the following: 11.18 −2.03

   a) 9.15
   b) 8.15
   c) 8.95
   d) 10.05

10. Last Saturday Joe was paid $4.20 for working 3.5 hours. How much was he paid per hour?

   a) $1.10
   b) $0.11
   c) $12.00
   d) $1.20

11. Round off the following decimal to the nearest tenth: 33.578

   a) 33.57
   b) 33.58
   c) 33.6
   d) 33.5

12. Add the following: 3.05 + .017

   a) .322
   b) 3.22
   c) 3.067
   d) 3.220

13. $\frac{1}{3} + \frac{1}{5} =$

   a) $\frac{2}{8}$
   b) $\frac{1}{4}$
   c) $\frac{8}{15}$
   d) $\frac{8}{8}$

14. Multiply the following: 3.15 x .01

   a) 3.15
   b) .0315
   c) .315
   d) 31.5

15. $\frac{1}{4} \times \frac{3}{2} =$

   a) $\frac{12}{2}$
   b) $\frac{4}{6}$
   c) $\frac{7}{4}$
   d) $\frac{3}{8}$

GO ON TO THE NEXT PAGE

MARK YOUR ANSWERS ON THE SEPARATE ANSWER SHEET

16. Give the mixed number for $\frac{11}{3}$

a) $\frac{3}{11}$

b) $3\frac{2}{3}$

c) $4\frac{1}{3}$

d) $2\frac{5}{3}$

17. $\frac{5}{3} \div \frac{2}{7} =$

a) $\frac{6}{35}$

b) $\frac{10}{21}$

c) $\frac{35}{6}$

d) none of these

18. Change .375 to a common fraction

a) $\frac{3}{8}$

b) $\frac{2}{5}$

c) $\frac{5}{12}$

d) $\frac{1}{4}$

19. Millwood has a population of 3651 and Deepdale has a population of 2602. What is the ratio of Deepdale's population to Millwood's?

a) 2651 to 2602

b) 2602 to 3651

c) 2602 to 6253

d) 1049 to 2602

20. Find n: $\frac{7}{14} = \frac{n}{6}$

a) 2

b) 3

c) 4

d) 5

21. Change the fraction $\frac{3}{7}$ to a decimal. Round your answer to 3 decimal places.

a) .285

b) .286

c) .428

d) .429

22. Sherry walks 3 miles in 45 minutes. How long would it take her to walk 8 miles?

a) 135 minutes

b) 24 minutes

c) 360 minutes

d) 120 minutes

GO ON TO THE NEXT PAGE

APPENDIX J

NON-NORMED ACHIEVEMENT TEST FOR ALGEBRA

TEST ON ALGEB - FORM II

Edward C. Beardslee and Lars C. Jansson

Directions: Do not mark anything in your test booklet. Answers are to be recorded on the separate answer sheet. You will be provided with scratch paper for computation. This is a 40 minute test containing 32 items.

Do not begin until the teacher tells you to do so.

MARK YOUR ANSWERS ON THE SEPARATE ANSWER SHEET

1. Find the value of the following: (-3) x (-11) + 7 = ?

   (a) 40
   (b) -26
   (c) 12
   (d) -12
   (d) 26

2. John got 15 correct answers out of 20 questions on a spelling test. What percent did he get correct on the test?

   (a) 75%
   (b) 15%
   (c) 50%
   (d) 60%
   (e) 80%

3. Find the following sum: (-5) + 6 + (-3) + (-9) = ?

   (a) 11
   (b) -23
   (c) -13
   (d) 13
   (e) -11

4. If $\frac{3}{4}$ and $\frac{n}{36}$ and equivalent fractions, then n is?

   (a) 24
   (b) 18
   (c) 9
   (d) 27
   (e) 30

GO ON TO NEXT PAGE

MARK YOUR ANSWERS ON THE SEPARATE ANSWER SHEET

5. Evaluate the following the rules for the order of operations:
$26 - 3 \times 6 \div 2$

(a) 17
(b) 69
(c) 35
(d) 22
(e) 4

6. $7 \cdot x \cdot x \cdot y \cdot y \cdot y =$

(a) $7xy$
(b) $7x^2y$
(c) $7xy^2$
(d) $7x^2y^3$
(e) $7xy^3$

7. Which of the following properties is illustrated by the statement:
$2(x + y) = (x + y)2$

(a) commutative (addition)
(b) associative (addition)
(c) distributive
(d) commutative (multiplication)
(e) associative (multiplication)

8. For all values of the variables: $0(a) = 1(x) = ?$

(a) a
(b) x
(c) a + x
(d) 0
(e) 1

9. Complete the following sentence to make it true:
-7 __?__ -5

(a) <
(b) both > and <
(c) >
(d) =
(e) all of the above

GO ON TO THE NEXT PAGE

MARK YOUR ANSWERS ON THE SEPARATE ANSWER SHEET

10. A = {1,2,3,4}
B = {3,4,5}

A ∪ B = ?

(a) {Counting numbers less than 7}
(b) {4,5,6}
(c) {1,2,3,4,5}
(d) {3,4,5,6,7}
(e) none of the above

11. Find the reciprocal (multiplicative inverse) of $\frac{-2}{11}$

(a) $\frac{2}{11}$
(b) $\frac{2}{-11}$
(c) 11
(d) $\frac{11}{2}$
(e) $\frac{-11}{2}$

12. Alice found that b books were missing from the library shelf. Usually there are 127 books. How many are there now?

(a) (127b) books
(b) (127-b) books
(c) (127 + b) books
(d) (b - 127) books
(e) b books

13. $B = \{x | x \leq 7, x \epsilon D\}$
D = {odd counting numbers}

(a) {1,3,5}
(b) {1,2,3,4,5,6,7}
(c) {1,3,5,7}
(d) {1,2,3,4,5,6}
(e) {1,3,5,7,9}

GO ON TO NEXT PAGE

MARK YOUR ANSWERS ON THE SEPARATE ANSWER SHEET

14. If A = 2(ab + ac + bc), find A when a=3, b=6, and c=4.

(a) 26
(b) 66
(c) 108
(d) 13
(e) 54

15. While one of the following sets is closed under addition?

(a) {0,1,2}
(b) {counting numbers between 5 and 100}
(c) {counting numbers less than 100}
(d) {odd counting numbers}
(e) {even counting numbers}

16. Find the value of x which satisfies the equation:
5x - 4 = 3x + 10

(a) 2

(b) $\frac{3}{4}$

(c) 3

(d) $\frac{7}{4}$

(e) 7

17. Simplify the following: $(a^2b^3)^5$

(a) a^8b^7

(b) a^7b^8

(c) a^2b^3

(d) a^5b^5

(e) $a^{10}b^{15}$

GO ON TO THE NEXT PAGE

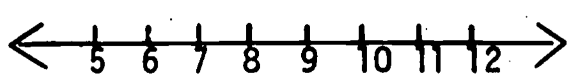
MARK YOUR ANSWERS ON THE SEPARATE ANSWER SHEET

18. Find the slope of the straight line with the equation: $y = -2x + 3$.

(a) 1
(b) -3
(c) 2
(d) 3
(e) -2

19. Which of the given properties is a property of the rational numbers but <u>not</u> a property of the integers?

(a) Additive Identity
(b) Commutative (multiplication)
(c) Multiplicative inverse
(d) Associative (Addition)
(e) Multiplicative Identity

20. 

Assuming that x represents a counting number, which of the following describes the indicated set?

(a) $\{x|x > 5 \text{ and } x < 10\}$

(b) $\{x|x < 5\}$

(c) $\{x|x < 10\}$

(d) $\{x|x < 5 \text{ and } x > 10\}$

(e) $\{x|x > 5\}$

21. For any real number K, the graph of $y = K$ is which kind of line.

(a) vertical
(b) horizontal
(c) oblique
(d) the graph is a point not a line
(e) none of the above

GO ON TO THE NEXT PAGE

MARK YOUR ANSWERS ON THE SEPARATE ANSWER SHEET

22. Express the following as one fraction: $\frac{3}{x} + \frac{2}{y} + \frac{3}{z}$

(a) $\frac{3yz + 2xz + 3xy}{xyz}$ (c) $\frac{3yz + 2xy}{x + y + z}$ (e) $\frac{8}{xyz}$

(b) $\frac{18}{xyz}$ (d) $\frac{8}{x + y + z}$

23. Find the solution set for the inequality: $3 - x > 8$

(a) $\{x | x > 11\}$
(b) $\{x | -x > 11\}$
(c) $\{x | x > 5\}$
(d) $\{x | x < -5\}$
(e) $\{x | x > -5\}$

24. Add the following polynomials: $(4x + 5x^2 - 3) + (8x - 3x^2) = ?$

(a) $14x - 3$ (d) $14x^2 - 3$
(b) $2x^2 + 12x - 3$ (e) $11x$
(c) $8x^2 + 12x - 3$

25. Reduce to lowest terms: $\frac{4y^2 - 8y}{12y}$; $y \neq 0$

(a) $\frac{y^2 - 8}{3}$ (d) $\frac{4y^2 - 2}{3}$

(b) $\frac{y^2 - 8y}{3y}$ (d) $\frac{y - 2}{3}$

(c) $\frac{y - 2}{3y}$

26. An equation of the form $Ax + By + C = 0$ where A and B are not both zero is a __________.

(a) term
(b) quadratic equation
(c) polynomial equation
(d) linear equation
(e) none of the above

GO ON TO THE NEXT PAGE

MARK YOUR ANSWERS ON THE SEPARATE ANSWER SHEET

27. Choose the rational number, R, which makes the following statement true.

$$\frac{3}{12} < R < \frac{4}{12}$$

(a) $R = \frac{3}{24}$

(b) $R = \frac{8}{24}$

(c) $R = \frac{3}{11}$

(d) $R = \frac{5}{13}$

(e) none of the above

28. Multiple the following: Assume that no denominator takes on the value zero.

$$\frac{3x + 3y}{x - y} \cdot \frac{x^2 - y^2}{3} = ?$$

(a) $\frac{3x^3 - 3y^3}{x - 3y}$

(b) $(x + y)^2$

(c) $\frac{3x^3 - 3y^3}{3x - y}$

(d) $\frac{x^3 - 3y^2}{x - y}$

(e) $\frac{x^3 - y^3}{x - y}$

29. Multiply the following: $(3x^3)(6 + 2x - 3x^2) - ?$

(a) $18x^3 + 6x^4 - 9x^6$
(b) $18 + 6x - 9x^2$
(c) $15x^3$
(d) $18x^3 - 9x^5 + 6x^4$
(e) None of the above

30. Divide $(12x^2 - 5x - 3)$ by $(3x + 1)$

(a) $4x + 1$
(b) $4x + 3$
(c) $4x - 3$
(d) $x - 1$
(e) $x + 1$

GO ON TO THE NEXT PAGE

MARK YOUR ANSWERS ON THE SEPARATE ANSWER SHEET

31. Find the value of $\sqrt{4k^4}$ where k is a non-negative real number.

(a) $2k^2$
(b) $4k$
(c) $2k$
(d) $4k^2$
(e) k

32. Multiple: $3(5\sqrt{2} + 7\sqrt{5})$

(a) $105\sqrt{10}$
(b) $36\sqrt{7}$
(c) $5\sqrt{6} + 7\sqrt{15}$
(d) $15\sqrt{6} + 21\sqrt{15}$
(e) $15\sqrt{2} + 21\sqrt{5}$

THE END

YOU MAY GO BACK TO ANY PART OF THE TEST AND CHECK YOUR WORK

APPENDIX K

ATTITUDE TOWARD MATHEMATICS SCALE

FORM B

Attitude Toward Mathematics
(Form B)

Marilyn N. Suydam and Cecil R. Trueblood
The Pennsylvania State University

This is to find out how you feel about mathematics. You are to read each statement carefully and decide how you feel about it. Then indicate your feeling on the answer sheet by marking:

A - if you strongly agree
B - if you agree
C - if your feeling is neutral
D - if you disagree
E - if you strongly disagree

1. Mathematics often makes me feel angry.
2. I usually feel happy when doing mathematics problems.
3. I think my mind works well when doing mathematics problems.
4. When I can't figure out a problem, I feel as though I am lost in a mass of words and numbers and can't find my way out.
5. I avoid mathematics because I am not very good with numbers.
6. Mathematics is an interesting subject.
7. My mind goes blank and I am unable to think clearly when working mathematics problems.
8. I feel sure of myself when doing mathematics.
9. I sometimes feel like running away from my mathematics problems.
10. When I hear the word mathematics, I have a feeling of dislike.
11. I am afraid of mathematics.
12. Mathematics is fun.
13. I like anything with numbers in it.
14. Mathematics problems often scare me.
15. I usually feel calm when doing mathematics problems.
16. I feel good toward mathematics.
17. Mathematics tests always seem difficult.
18. I think about mathematics problems outside of class and like to work them out.
19. Trying to work mathematics problems makes me nervous.
20. I have always liked mathematics.

21. I would rather do anything else than do mathematics.
22. Mathematics is easy for me.
23. I dread mathematics.
24. I feel especially capable when doing mathematics problems.
25. Mathematics class makes me look for ways of using mathematics to solve problems.
26. Time drags in a mathematics lesson.

APPENDIX L

ATTITUDE TOWARD COMPUTER-ASSISTED INSTRUCTION SCALE

Attitude Toward Computer Assisted Instruction

Revised by Marilyn N. Suydam
The Pennsylvania State University

This is to find out how you feel about CAI. You are to read each statement carefully and decide how you feel about it. Then indicate your feeling on the answer sheet by marking:

A - if you strongly agree
B - if you agree
C - if your feeling is neutral
D - if you disagree
E - if you strongly disagree

1. CAI helps me to learn quickly.
2. I prefer CAI to regular instruction.
3. I find myself just trying to get through the material in CAI, rather than trying to learn.
4. CAI makes me feel like doing my best work.
5. I feel the teacher helps me more in the CAI class than in other classes.
6. I feel there is too much material presented in the CAI course.
7. I feel that no one really cares whether I learn or not on CAI.
8. My feeling about the material was better before I was on CAI than it is now.
9. I feel as if I have a teacher just for me when I am on CAI.
10. I enjoy doing the assignments for my CAI class.
11. The CAI material seems to be planned just for me.
12. I would be happier if a teacher checked my progress more often as I work at the terminal.
13. I feel as if someone is talking with me when I am on CAI.
14. I would like to take all my courses using CAI.
15. I pay more attention to using the terminal than to learning the material.
16. I am worried that I might not be understanding the material in CAI.
17. I would rather learn without CAI.
18. I enjoy working at the terminal.
19. I feel that CAI is a waste of time.
20. I feel I can work at my own speed on CAI.
21. Working at the terminal becomes boring.

22. The CAI material moves too slowly for me.
23. I feel satisfied with what I learn on CAI.
24. I feel tense when working at the terminal.

APPENDIX M

ATTITUDE TOWARD THE INSTRUCTIONAL SETTING SCALE
FORM B

Attitude Toward the Instructional Setting
(Form B)

Marilyn N. Suydam and Edward C. Beardslee
The Pennsylvania State University

This is to find out how you feel about this class. You are to read each statement carefully and decide how you feel about it. Then indicate your feeling on the answer sheet by marking:

A - if you strongly agree
B - if you agree
C - if your feeling is neutral
D - if you disagree
E - if you strongly disagree

1. Anyone who does not take this class is missing something.
2. Too much work is required for this class.
3. The teacher really listens to me in this class.
4. This class is fun.
5. My work is watched too closely in this class.
6. It is easy to get help in this class.
7. This class makes me feel that I am important.
8. The slow worker doesn't have a chance in this class.
9. No one pays any attention to me in this class.
10. I could learn more working at a job than in this class.
11. I find it very hard to work in this class.
12. I wish I could take more classes like this.
13. There are many interesting things to do in this class.
14. If a student does not learn in this class, it is his own fault.
15. I dislike this class more than any other class I have taken.
16. I always know how well I am doing in this class.
17. This class is boring.
18. Nothing is done in this class to keep me interested.
19. This class is great.
20. I like the way the teacher teaches this class.
21. I enjoy doing the work in this class.
22. I cannot learn what I want to learn in this class.
23. It is hard to pay attention in this class.

24. This class is like a prison.
25. I look forward to coming to this class.
26. I work more with other students in this class than I do in other classes.
27. This class is not worth the time it takes.
28. I feel the teacher does not help me in this class.
29. Time seems to fly in this class.
30. I have no freedom in this class.

APPENDIX N

TABLES

Table N-1

Coefficients of Reliability for Achievement Tests

	School	Course	Group	Reliability Coefficient Pretest	Reliability Coefficient Posttest
Non-normed Achievement Tests	Pittsburgh	General Mathematics	CAI	.73	.83
			Cohort	.69	.84
	Philadelphia		CAI	.59	.76
			Cohort	.75	.81
	Pittsburgh	Algebra	CAI	.30	.68
			Cohort	.62	.79
	Philadelphia		CAI	.45	.74
			Cohort	.48	.69
Normed Achievement Tests		General Mathematics	CAI	.87	.85
			Cohort	.76	.82
	Philadelphia		CAI	.67	.64
			Cohort	.70	.69
	Pittsburgh	Algebra	CAI	.35	.70
			Cohort	.58	.78
	Philadelphia		CAI	.57	.71
			Cohort	.55	.68

Table N-2

Coefficients of Reliability for Attitude Scales

Scale	School	Course	Group	Reliability Coefficient First	Second Administration	Third
Attitude Toward Mathematics	Pittsburgh	General Mathematics	CAI	.88	.88	.89
			Cohort	.92	.94	.93
	Philadelphia		CAI	.89	.92	.93
			Cohort	.90	.93	.93
	Pittsburgh	Algebra	CAI	.91	.92	.91
			Cohort	.94	.95	.96
	Philadelphia		CAI	.93	.94	.95
			Cohort	.91	.93	.95
Attitude Toward CAI	Pittsburgh	General Mathematics	CAI	.79	.84	.87
	Philadelphia		CAI	.86	.86	.87
	Pittsburgh	Algebra	CAI	.85	.86	.87
	Philadelphia		CAI	.89	.90	.89
						(spring)
Attitude Toward Instructional Setting	Pittsburgh	General Mathematics	CAI			.92
			Cohort			.92
	Philadelphia		CAI			.93
			Cohort			.94
	Pittsburgh	Algebra	CAI			.89
			Cohort			.95
	Philadelphia		CAI			.94
			Cohort			.94

Table N-3

Analysis of Variance Summary Table for Data from
Non-normed Achievement Test for Pittsburgh General Mathematics Groups

Source	SS	MS	df	F-ratio	p Less Than
Between Subjects					
Instructional Mode	452.21	452.21	1	10.72	.001
Error	6410.64	42.18	152		
Within Subjects					
Testing	1184.47	1184.47	1	85.18	.001
Mode x Testing	189.80	189.80	1	13.65	.001
Error	2113.73	13.91	152		
Total	10350.85		307		

Table N-4

Analysis of Variance Summary Table for Data from
Non-normed Achievement Test for Philadelphia General Mathematics Groups

Source	SS	MS	df	F-ratio	p Less Than
Between Subjects					
Instructional Mode	193.24	193.24	1	4.12	n.s.
Error	11111.80	46.89	237		
Within Subjects					
Testing	448.47	448.47	1	14.50	.001
Mode x Testing	130.52	130.52	1	4.22	n.s.
Error	7328.51	30.92	237		
Total	19212.54		477		

Table N-5

Analysis of Variance Summary Table for Data from
Non-normed Achievement Test for Pittsburgh Algebra Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Instructional Mode	294.95	294.95	1	14.20	.001
Error	5027.93	20.78	242		
Within Subjects					
Testing	1674.62	1674.62	1	190.32	.001
Mode x Testing	182.06	182.06	1	20.69	.001
Error	2129.32	8.80	242		
Total	9308.88		487		

Table N-6

Analysis of Variance Summary Table for Data from
Non-normed Achievement Test for Philadelphia Algebra Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Instructional Mode	1034.65	1034.65	1	39.23	.001
Error	7042.47	26.38	267		
Within Subjects					
Testing	4351.12	4351.12	1	247.49	.001
Mode x Testing	390.68	390.68	1	22.22	.001
Error	4694.21	17.58	267		
Total	17513.13		537		

Table N-7

Analysis of Variance Summary Table for Data from
Normed Achievement Test for Pittsburgh General Mathematics Groups

Source	SS	MS	df	F-ratio	p Less Than
Between Subjects					
Instructional Mode	650.36	650.36	1	8.61	.004
Error	11487.20	75.57	152		
Within Subjects					
Testing	559.17	559.17	1	26.31	.001
Mode x Testing	20.57	20.57	1	< 1.0	n.s.
Error	3230.76	21.26	152		
Total	15948.06		307		

Table N-8

Analysis of Variance Summary Table for Data from
Normed Achievement Test for Philadelphia General Mathematics Groups

Source	SS	MS	df	F-ratio	p Less Than
Between Subjects					
Instructional Mode	232.24	232.24	1	5.28	n.s.
Error	10422.30	43.98	237		
Within Subjects					
Testing	254.81	254.81	1	10.28	.002
Mode x Testing	14.76	14.76	1	< 1.0	
Error	5876.93	24.80	237		
Total	16801.04		477		

Table N-9

Analysis of Variance Summary Table for Data from Normed Achievement Test for Pittsburgh Algebra Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Instructional Mode	1063.77	1063.77	1	41.22	.001
Error	6245.27	25.81	242		
Within Subjects					
Testing	1249.92	1249.92	1	105.02	.001
Mode x Testing	7.24	7.24	1	< 1.0	n.s.
Error	2880.34	11.90	242		
Total	11446.54		487		

Table N-10

Analysis of Variance Summary Table for Data from Normed Achievement Test for Philadelphia Algebra Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Instructional Mode	334.23	334.23	1	10.15	.002
Error	8794.23	32.94	267		
Within Subjects					
Testing	1956.65	1956.65	1	102.22	.001
Mode x Testing	33.34	33.34	1	1.74	n.s.
Error	5111.01	19.14	267		
Total	16229.46		537		

Table N-11

Analysis of Variance Summary Table for Data from
Attitude Toward Mathematics Scale for Pittsburgh General Mathematics Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Instructional Mode	219.50	219.50	1	< 1.0	n.s.
Error	51136.40	506.30	101		
Within Subjects					
Testing	17592.70	8796.36	2	55.21	.001
Mode x Testing	1604.73	802.36	2	5.04	.007
Error	32181.90	159.32	202		
Total	102735.23		308		

Table N-12

Analysis of Variance Summary Table for Data from
Attitude Toward Mathematics Scale for Philadelphia General Mathematics Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Instructional Mode	2384.42	2384.42	1	5.24	n.s.
Error	67801.90	455.05	149		
Within Subjects					
Testing	32185.20	16092.60	2	83.04	.001
Mode x Testing	8952.34	4476.17	2	23.10	.001
Error	57749.80	193.79	298		
Total	169073.66		425		

Table N-13

Analysis of Variance Summary Table for Data from Attitude Toward Mathematics Scale for Pittsburgh Algebra Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Instructional Mode	787.76	787.75	1	1.48	n.s.
Error	102888.00	533.10	193		
Within Subjects					
Testing	13281.40	6640.68	2	45.26	.001
Mode x Testing	748.79	374.40	2	2.55	n.s.
Error	56635.90	146.73	386		
Total	174341.85		584		

Table N-14

Analysis of Variance Summary Table for Data from Attitude Toward Mathematics Scale for Philadelphia Algebra Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Instructional Mode	247.94	247.94	1	< 1.0	n.s.
Error	123451.00	605.15	204		
Within Subjects					
Testing	1808.43	904.21	2	5.05	.007
Mode x Testing	3262.44	1631.22	2	9.11	.001
Error	73026.50	178.99	408		
Total	201796.31		617		

Table N-15

Analysis of Variance Summary Table for Data from Attitude Toward Computer Assisted Instruction Scale for Pittsburgh General Mathematics Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Error	30101.70	501.70	60		
Within Subjects					
Testing	6195.16	3097.58	2	11.16	.001
Error	33317.50	277.65	120		
Total	69614.36		182		

Table N-16

Analysis of Variance Summary Table for Data from Attitude Toward Computer Assisted Instruction Scale for Philadelphia General Mathematics Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Error	38245.70	347.69	110		
Within Subjects					
Testing	2506.20	1253.10	2	14.95	.001
Error	18440.50	83.82	220		
Total	59192.40		332		

Table N-17

Analysis of Variance Summary Table for Data from Attitude Toward Computer Assisted Instruction Scale for Pittsburgh Algebra Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Error	44468.60	313.16	142		
Within Subjects					
Testing	5421.71	2710.85	2	40.10	.001
Error	19197.00	67.59	284		
Total	69087.31		328		

Table N-18

Analysis of Variance Summary Table for Data from Attitude Toward Computer Assisted Instruction Scale for Philadelphia Algebra Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Error	95593.60	620.74	154		
Within Subjects					
Testing	107440.00	53720.00	2	125.71	.001
Error	131621.00	427.34	308		
Total	334654.60		464		

Table N-19

Analysis of Variance Summary Table for Data from Ability/Achievement Tests for Pittsburgh General Mathematics Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Ability	280.33	280.33	1	7.08	n.s.
Error	871.58	39.62	22		
Within Subjects					
Achievement	330.75	330.75	1	32.89	.001
Ability x Achievement	12.00	12.00	1	1.19	n.s.
Error	221.25	10.06	22		
Total	1715.91		47		

Table N-20

Analysis of Variance Summary Table for Data from Ability/Achievement Tests for Philadelphia General Mathematics Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Ability	519.30	519.30	1	20.91	.001
Error	745.19	24.84	30		
Within Subjects					
Achievement	206.64	206.64	1	7.04	n.s.
Ability x Achievement	6.75	6.75	1	<1.0	n.s.
Error	881.11	29.37	30		
Total	2358.99		63		

Table N-21

Analysis of Variance Summary Table for Data from Ability/Achievement Tests for Pittsburgh Algebra Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Ability	144.08	144.08	1	6.85	n.s.
Error	1073.51	21.05	51		
Within Subjects					
Achievement	627.96	627.96	1	75.33	.001
Ability x Achievement	84.89	84.89	1	10.18	.002
Error	425.15	8.34	51		
Total	2355.59		105		

Table N-22

Analysis of Variance Summary Table for Data from Ability/Achievement Tests for Philadelphia Algebra Groups

Source	SS	MS	df	F-ratio	P Less Than
Between Subjects					
Ability	112.67	112.67	1	4.77	n.s.
Error	1110.33	23.62	47		
Within Subjects					
Achievement	943.02	943.02	1	61.73	.001
Ability x Achievement	3.93	3.93	1	<1.0	n.s.
Error	718.05	15.28	47		
Total	2888.00		97		

Table N-23

Correlation Coefficients for Previous Achievement[a] with (Current) Achievement and with Attitudes

			Achievement/ Previous Achievement				Achievement/ Previous Achievement			
	N		Non-normed		Normed		Math Att.		CAI Att.	
	CAI	Cohort	CAI	Cohort	CAI	Cohort	CAI	Cohort	CAI	Cohort
Pittsburgh General Mathematics	47	26	.71*	-.02	.58*	.06	.45*	-.07	.25	-
Philadelphia General Mathematics	61	19	.37*	.49	.39*	.28	.16	-.30	.03	-
Pittsburgh Algebra	107	46	.44*	.42*	.57*	.47*	.26*	.37	.02	-
Philadelphia Algebra	116	34	.53*	.22	.30*	.28	.42*	.24	.11	-

[a]Previous achievement is defined by Mathematics Achievement Test Scores for 1969-70.

*Significant at $p < .01$.

Table N-24

Correlation Coefficients for Attendance[b] with (Current) Achievement and with Attitudes

	N		Achievement/Attendance				Attitude/Attendance			
			Non-normed		Normed		Non-normed		Normed	
	CAI	Cohort	CAI	Cohort	CAI	Cohort	CAI	Cohort	CAI	Cohort
Pittsburgh General Mathematics	47	26	-.21	-.03	-.13	.16	-.30	-.08	-.11	-
Philadelphia General Mathematics	61	19	.21	-.22	.19	-.29	.19	.26	.19	-
Pittsburgh Algebra	107	46	-.05	-.34	-.06	-.26	.13	-.11	.22	-
Philadelphia Algebra	116	34	-.35*	.04	-.19	.16	-.25	-.05	-.11	-

[b]Attendance is defined by number of absences for 1970-71.

*Significant at $p < .01$.

Table N-25

Correlation Coefficients for Number of Years in School with (Current) Achievement

	N		Achievement/Years in Sch.				Attitude/Years in Sch.			
			Non-normed		Normed		Non-normed		Normed	
	CAI	Cohort	CAI	Cohort	CAI	Cohort	CAI	Cohort	CAI	Cohort
Pittsburgh General Mathematics	47	26	-.28	-.17	-.19	.08	-.06	.17	-.03	-
Philadelphia General Mathematics	61	19	-.13	-.20	-.31	.09	-.10	.38	-.28	-
Pittsburgh Algebra	107	46	-.23	-.31	-.16	-.44	-.12	-.25	-.01	-
Philadelphia Algebra	116	34	-.07	.08	-.04	.06	.02	-.02	-.16	-

Table N-26

Correlation Coefficients for Amount of Time On-line with (Current) Achievement

		Achievement/Time On-line		Attitude/Time On-line	
	N	Non-normed	Normed	Math Attitude	CAI Attitude
Pittsburgh General Mathematics	47	.17	-.04	.19	.19
Philadelphia General Mathematics	61	.04	-.02	-.07	.04
Pittsburgh Algebra	107	.19	.13	.14	.12
Philadelphia Algebra	116	.11	.02	-.16	.21

APPENDIX P

REACTIONS OF STUDENTS

Descriptive Data

The information in this section is obviously subjective, representing the reactions of those involved in the project: first, the students, and second, the teachers. Lastly, a brief description of each type of classroom--CAI and non-CAI is included.

Reactions of Students[1]

I enjoy being on line, and it is a lot better than a regular class.

I like math because it is taught in a very interesting way.

A student should be able to stay on line longer.

I liked math in a way because it is not as boring as other subjects I have.

In a few problems that I don't understand, I feel I need more help. I like math but sometimes it is boring.

I did not like math when I am taught by a teacher. The computers helped me understand and work at my own speed.

I like math; it is fun and neat.

I think the course is very good. It also is fun too. I hope to get this course next year.

I think it is good because you can work at your own pace. It also teaches you much better than a teacher.

Working with the computer is pretty cool.

Teachers who are in a hurry often neglect to explain fully to students and make the subject uninteresting.

Mathematics has always been a difficult subject for me. I understand it better.

I do not understand math, the kind of math we get. I feel we should get to pick what we want.

Teachers do not spend enough time with the student individually and that makes mathematics harder.

I like it because I do well with it.

The computer is almost human. It rewards me when I am right.

I think I would take it if I didn't have to.

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[1] These comments have been edited for readability factors such as grammar and spelling.

I don't like mathematics very much. When I just learn something we go on. I like using the terminal but I don't. The computers are very interesting but math is not interesting.

I find I need more understanding off line. Much more. I do not know where I am supposed to be till the end. I would like to know before the end.

Math depends on the way you are taught. It's a very interesting subject because it helps you in most things you do.

There are too many rules you have to memorize.

I like math since it is interesting and is fun and challenging to answer problems and puzzles.

I find math a hard subject, but I think that it is also interesting. I had an excellent teacher who made everything easier to understand. The only thing wrong all year is all the explaining on line. Sometimes I have seen four screens full of explanations. Other than that, I feel this algebra course (on line) has been perfect.

I like it. It does help you in every thing you do.

Well I really liked working or studying mathematics. I wish all the subjects were like this one.

I like math because there is always something new to learn.

The reason I don't like it is that I can't get the correct understanding of the problems, even with the teacher's help sometimes, and when I do think that I understand it I have the wrong understanding.

In reference to the question that asked about good mathematics students being wook-worms; the only reason that it's usually true is because most teaching methods employed today are really archaic. However, I do feel that the CAI system is very effective. It has continued to provide motivation and stimulation throughout the course and has really boosted my interest in math.

I did not like math on the computer too well because it does not explain as well as a teacher. It was fun and you could go as fast or as slow as you wanted. The teacher should let you work at your own rate and not try to keep you up with others.

I like some parts of math but not too many parts. I would rather not learn advanced things but wait until I get to that step. I enjoy doing problems that I do not have trouble doing. I think it was a good idea to have math on the computers.

I can not understand it half of the time and won't ask for help, because if I can not do it with a computer's help then the teacher sure won't be able to help. And I feel that this computer has helped me a little more than the teacher and wish that I had computers instead of some teachers, I may have done better.

Mathematics help me see how good I am in my brain. It is all so much fun.

Math is alright until you get too many problems with large numbers then it gets boring and on your nerves.

I like the computer math teaching,--fun, easier and it explains the problem at your own sp[illegible]. I have the best grades in the computer math than in any oth[illegible] courses. And it is far more better than a teacher, and I am looking forward to next year for algebra on the computer.

I liked this course in mathematics more than other mathematics courses, because I felt there was always something I could understand. If I did not there usually was someone who did who could help me. Also there were sheets to help you. You did not have to stay behind with the other kids, you were free to move on as soon as you understood the course. I think this is what schools need to help students along.

I do not like math at all but the computer has made me like it a little bit. It's hard to keep up with a whole class but the computer has made it easier.

All and all it is the nicest and the most fun way of learning and in computer math this year I learned the most I have ever learned.

APPENDIX Q

REACTIONS OF TEACHERS

Reactions of Teachers in Pittsburgh

Course Structure

For these students, parts of chapters 1 and 2 in algebra may not be essential, but the entire course would need to be restructured if these were deleted.

Repetitious drill and practice is needed for these students, rather than reading a logical development as required in CAI ALGEB. (Some terminology was above the reading level of the students.) They are receiving individual instruction, but from the teacher, not the computer. It was assumed that all algebra students could do arithmetic: not all of these students can. Testing is needed to determine arithmetic proficiency before they take algebra. CAI ALGEB would be more appropriate for schools where students' reading ability is commensurate with their grade level. The students are oriented toward one task at a time: it was difficult for them to follow the structuring and "breakdown" by steps.

More decisions in a CAI program should be based on student responses, with less emphasis on decision-making by students. They don't like to be told that they're having trouble or doing poorly: they'll decide to proceed no matter what their score was.

There may need to be both a "basic" and a "standard" algebra program. About one-fourth could complete the course in one year; about one-half, in two years; the remaining one-fourth might never finish.

If only one CAI course were to be used, it should be GENMA. Because it is review, it turned out to be more self-sufficient. Algebra requires more teacher help.

Student Behavior

Can a student of the type in this school be allowed to proceed at his own rate? Or does the pace need to be set by the teacher? The course was planned for a 160-day year, but most students need more than this (especially when such factors as the absentee rate, and the late start, [the system was not operating until the middle of October due to a strike] are considered).

In GENMA some students had to wait for course material that had not been delivered.

The students did not move from one type of material to another (i.e., from on-line to off-line) as readily as had been expected. They would prefer to spend their entire time either on- or off-line. They are not oriented toward continual work: they view each activity as "a day's work."

Orientation is a key to develop the individual progress concept. The students learned how the program is scoring, and therefore what to do to "beat" the system (e.g., signing off so errors were not recorded). They did not "get the idea" of the program helping them to learn: they wanted to put in only the correct answer. Therefore they waited for the teacher to confirm their answers. It was punishment for them to have to redo material or go through a loop.

The students did not progress far enough in the program. They need more "structuring." The teachers became frustrated. But they recognize that once a rate of progress is designated, the program may stop being individualized.

With CAI, the students have a chance to "cover" more material, but the program may give a false sense of security, i.e., that students are learning when in fact they may not be.

Some students like CAI to the extent that they would want all classes to be on-line; some hate it. Many would elect to take one course on line next year (if it were possible).

With CAI, the teacher becomes a "reactor," responding to individual situations at each point in time. Sometimes he may be providing too much help for the students.

Utilization Pattern

Assigning two students to a terminal was not effective, especially because of machine breakdowns. However, the students tended to get "attached" to one terminal.

A better logistical base is needed, and a better orientation of both students and teachers to the use of CAI. Thirty students per teacher is too many, especially at the beginning; after all are oriented, thirty might be plausible. The students need attention and demand attention.

For general mathematics, it might be preferable to have students on-line for the entire time (since the content is a review of previously-taught material). For algebra, it might be better to use on-line materials for practice, only (since algebra is largely new content).

The greatest strength of CAI is that it allows for student absences. How students who are absent as frequently as these students are can learn anything in a regular class seems incredible. New students (late entrants, transfer) can take tests and be placed at any point in the year. Students can move (and have moved) from general mathematics to algebra. They can come in after school to make up missed class time. Regular class becomes a "hassle" because they're absent so often and it becomes impossible to make up work since it takes so much time. More provision, however, needs to be made in CAI scheduling for students to make up time missed (to have extra time on terminal).

It is necessary to develop a basic philosophy of grading: is some uniformity across types of classes or across CAI classes necessary or possible?

Computer System

The mechanical difficulties combined with the (low) frustration level of the students caused problems: they were "almost ready to kick the machines apart." The system is slow, and "klunking" on the space bars is almost continual. The loading and unloading of image projectors is a problem. In addition, there is need for more technical help, and preferably an available full-time systems operator. The teachers have had to learn to operate and repair the systems. CAI is experimental, but these problems must go; a system that will operate better is needed.

Physical Facilities

The room arrangement with terminals in the center was poor: it was difficult to reach all students who demanded attention. The room with terminals around the walls, and work tables in the center, was better.

Reactions of Teachers in Philadelphia

Course Structure

The ALGEB course is good but could be improved. Not enough material was covered to prepare students for algebra II. There was too much emphasis on "learning at your own rate:" a minimum amount of material which must be covered should be designated.

In ALGEB, there are large masses of material with too few "breaks." Objectives should be specified for smaller units of material.

The on-line materials should be designed as a complete package. There was some disagreement between teachers and administrative personnel (at CAI Lab, PSU) over what should be on-line and what should be off-line. Perhaps the task was too large; at any rate there was too much emphasis on the computer. The computer materials should be as succinct as possible: it can't do the entire job.

The course does need additional drill materials. Students have been "schooled" to expect a "paper collection," so the switch to the more abstract on-line mode of CAI must be backed by physical materials--"handouts" or worksheets.

The variety involved in teaching both on- and off-line classes is good for both teachers and their students.

Students should have more choice: they come with different backgrounds and understanding, and shouldn't be forced through the program. However, when choices were offered in the program, they 1) were not always aware of what they were choosing and 2) rarely chose to go back and redo previous sections.

For the student who fails a test with 65 percent, there is no opportunity to retest: they need added questions and material, an opportunity for success.

There should be tests administered to determine the student's mode of learning (iconic, etc.); then he should be given computer materials which are best suited to him. Diagnosis is essential.

There is a great deal of material that was either 1) too hard, (especially for GENMA) or 2) there was insufficient time to use (especially for ALGEB).

There appears to have been an assumption that printed materials are sufficient; however, other audiovisual aids are also needed. Only one of 40 aids and games was used extensively: there wasn't enough opportunity for exploration with the remaining materials. Some games were too abstract; some had to be "taught" and were not self-motivating. More materials such as those from the Madison Project should be used.

The general structure of the on-line materials "isn't bad" - there's no need to change them structurally. But the access to off-line materials should be streamlined.

Student Behavior

Students did not behave much differently from the way they behave in a regular class. It was a little more difficult to maintain control when some students were disruptive. They should have a choice of taking a CAI or a regular class. Most, however, liked working at the machine, though a few took advantage of the situation by becoming noisy, not working consistently, etc.

Can 14 and 15 year-olds work effectively with computers--or do they need the interaction with others?

Students were more interested in getting a positive response (feedback) than in learning. They have found ways to "beat the system" to assure their getting the correct answer input; e.g., writing down correct answers to quizzes, or proceeding without answering until the answer is given to them. There is an assumption that the on-line materials did teach, because students got through, but there is some lack of understanding of concepts evident.

One decided advantage of CAI is the opportunity it affords students to "make up" work.

Most GENMA students are in Chapter 9 (at the end of May); they could have "covered" more, but they did progress quite well.

The major problem was with the off-line activities for remediation and enrichment in GENMA. The students expect to be rewarded by not doing anything; most are not motivated to do extra work. They liked the games, but not the "application" worksheets. The off-line materials were helpful; however, the students could work faster off-line and thus could get too far ahead of the on-line program, then, they needed to wait to get on-line instruction, as well as waiting for the teacher to check their off-line work.

The GENMA course was the more successful, based on assumptions of what the students would probably have learned in a regular class. Discipline problems were "practically nill:" the students seemed motivated and didn't mind criticism. The materials are generally well-presented, and most of the students are successful.

Utilization Pattern

There is more to do in the off-line area than there is to do in a regular classroom. More teacher-led off-line time is needed: individualizing instruction takes a great deal of time. Thirty students per class is too many; twenty should be the maximum number assigned. The teacher can't effectively "remediate" thirty students. The students need more training in working together and helping each other.

Computer System

The light pens were also "vulnerable" to problems. Generally, computer hardware problems were not extensive, though the speed of the system left much to be desired.

The image projector was the cause of 80 percent of the breakdowns. It is strongly suggested that the image projector be eliminated, and replaced with a looseleaf notebook of diagrams and illustrations.

Physical Facilities

The lay-out of the room (an inverted U, with the computer in the center portion) was good, although partitions between those on- and off-line would be helpful.

A "free-work area," different from the work tables, should be provided so there is more seclusion for playing games and other manipulative activities without bothering those working.

Larger partitions are needed between terminals.

The off-line groups should be sub-divided further, with two or three students at a table, not six or seven.

Staffing

If another course were to be written, more help from programers should be provided; the graduate assistants could be eliminated. Those who are helping should 1) have "good CAI proficiency," and 2) be able to follow directions. There were difficulties because of the staff not being education-oriented. The development of the course materials must be "overseen" by an experienced classroom teacher from the area where the course will be used, not by someone at the college-level who has been away from the classroom too long. Help is needed with innovative ideas--but the help should be from someone who knows what's going on.

Full-time, continuous help from the mathematics education faculty was needed. The team doesn't have to be large: two or three programers and one or two teachers (no more than three).

There was some question over where the authority to make decisions resided (at CAI Lab, PSU). Too many people were making decisions; when material was rejected, the teachers had no knowledge of who rejected it. Suggestions were usually negative ("no," "delete," etc.): constructive criticism would have helped.

The teacher's perspective changes with experience: those experienced should form the nucleus of any team to develop a new course.

APPENDIX R

CLASSROOM OBSERVATION FORM

School______________ Teacher______________ Subject______________ Time______________ Date______________

Intervals (5 min.)

	1	2	3	4	5	6	7	8	9
TYPE OF ACTIVITY introductory routines									
teacher presentation									
teacher questioning students									
students questioning teacher									
student/student discussion									
mathematics laboratory									
testing									
individual work									
MATERIAL USE chalkboard									
textbook/supplementary									
worksheet/workbook									
visual aid (CAI)									
ORIENTATION toward individual students									
subject-oriented									
STUDENT BEHAVIOR "orderly"/responsive									
undercurrent/inattentive									

	Intervals (5 min.) 1	2	3	4	5	6	7	8	9
CLIMATE formal/control-oriented									
informal/innovative									
GROUPING large/total: teacher-directed									
small: teacher-directed									
small: student initiated/ informal									
individual work									