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The greater part of this progress report embraces a series of research reports which represent empirical findings during the 1967 academic year. They range from results derived from the first field testing of the college physics, multi-media CAI course, through a series of specific experimental studies focusing on learning and adaptive variables open to manipulation within CAI. One part of the report depicts plans and phased objectives for the major projects within the CAI Center. Plans are continued for a collegiate physics course, the CAI course in social welfare, and the Intermediate Science Curriculum Study course. Activities have been inaugurated for teacher recruitment and placement, the use of systems concepts within education, and accompanying data management and analysis programs required to facilitate research efforts. Another section presents studies in progress, and these range from the use of CAI in collegiate counseling processes to the use of the CAI system to study discrimination processes under varying attitudinal reinforcement conditions. An appendix is provided. [Not available in hard copy due to marginal legibility of original document.] (Author/GO)

SEMIANNUAL PROGRESS REPORT

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PREPARED BY

Duncan N. Hansen, Walter Dick, and

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CAI CENTER

Institute of Human Learning

FLORIDA STATE UNIVERSITY

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Report Number 6
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COMPUTER-ASSISTED INSTRUCTION CENTER
INSTITUTE OF HUMAN LEARNING
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I. INTRODUCTION

The Computer-Assisted Instruction Center at Florida State University has been pursuing a broad range of research topics derived from the application of computers and related media technology to instructional processes. This general research focus has led to a major study of the developmental requirements and benefits from an autonomous course in undergraduate physics. Within this CAI physics project, we have been studying the nature of learning problems, facilitating teaching strategies, and the role of media for the fostering of optimal end-of-course performance. In a related vein, we have been utilizing the systems model and CAI in the deriving of newer forms of evaluative techniques that are operationally beneficial to curriculum authors. In pursuing these broad goals dealing with instructional and evaluative techniques based on CAI, we have performed a series of learning and personality related experimental studies. Most of these short-term experimental studies are originated in and coordinated with a graduate training program in educational technology. Thus, the CAI Center has been striving to coordinate and manage these multiple research and developmental activities in order to contribute to a better understanding of the role of computers and media technology within a wide variety of instructional systems.

This Semiannual Progress Report has been organized into three major sections. The first section represents the plans and phased objectives for the major projects within our Center. In addition to continuing plans for a collegiate physics course, the Intermediate Science Curriculum Study course, and the CAI course in social welfare, we have inaugurated activities relating to teacher recruitment and placement, the use of systems concepts within education, and accompanying data management and analysis programs required to facilitate our research efforts. As can be viewed in the Table of Contents, there is a substantive report on each of these projects.

As a representative sample of some of the more delimited experimental studies, the second section presents three studies which are now in progress. These range from the use of CAI in collegiate counseling processes to the use of the CAI system to study discrimination processes under varying attitudinal/ reinforcement conditions.

The major bulk of this Semiannual Progress Report is a series of research reports representing our empirical findings during the past academic year. These reports range from results derived from the first field testing of the college physics, multi-media CAI course through a series of specific experimental studies focusing on learning and adaptive variables open to manipulation within CAI. Each of these reports is self-contained and can be reviewed in the Table of Contents. In essence, these reports represent the substantive research progress achieved by the CAI Center.

II. MAJOR CAI PROJECTS--PLANS AND DEVELOPMENTS

A. Computer-Assisted Instruction in Introductory Physics

The first field test of the computer-based introductory physics course was completed in December of 1967. A description of the preparation of this first version of the CAI course as well as the field test learning results can be found in Section IV. This progress report reviews in detail all of the learning results as well as consideration of operational logistics and attitude reactions on the part of the students. In regards to future plans for the project, the staff has been pursuing appropriate course revisions based on the item performance and error analysis results from this first field test.

Authors have been analyzing specific learning difficulties in order to improve the program. All of the concept film presentations have been reanalyzed and more appropriate accompanying audio and printed materials are being prepared. In addition, the breadth and depth of the audio lectures are being both extended and elaborated. A wider range of questions dealing with concept mastery are also being included in order to allow for even greater individualization.

In the spring of the 1967-68 academic year, we plan to provide a more rigorous evaluation of a second version of this multi-media computer-based physics course. We will carefully select 40 participants. These will be selected according to sex (i.e., 20 males and 20 females) and prior physics instruction in high school. For cross-group comparison, a comparable selection procedure will be followed for the partial CAI group which receives review and practice prior to the mid-term and final exams, and a conventional group that will have no exposure to CAI. These groups will be matched according to verbal and quantitative scores on the Florida Twelfth Grade Entrance Examination, as well as age.

In addition, we plan to investigate lesson content by media by aptitude interactions. In order to facilitate this overall analysis, we plan to measure all participants on (1) a quantitative reasoning test; (2) a listening test; (3) a reading test, and (4) a problem-solving test. In regards to the affect domain, we plan to embed anxiety measures within each lesson in order to gain an anxiety/status report on each student. In addition, we will collect measures on impulsivity in order to detect whether learning rates are determined from this personality factor. The attitude measures towards this technological approach to instruction have been both extended in regards to man-machine characteristics. We trust that the spring field test will provide us with definitive results by which to confirm hypotheses related to the appropriateness of computer-controlled media types for students with given learning and personality characteristics.

B. The Intermediate Science Curriculum Study--Future Planning

During 1968-69, the Intermediate Science Curriculum Study will continue to use the CAI system as a vehicle for evaluating the science materials which are being designed for regular classroom usage. (See papers by Snyder and Dick in Section IV of this report.) The major purpose of the current CAI instruction of seventh grade students is to gather specific response data in order to provide the course authors with empirical data on the students' learning performance. The detailed computerized data analysis system which is required for this task has been under development during the current academic year. Summarized data from this system is currently being provided to the ISCS staff for their use in the preparation for the revision process.

In addition to continuing the CAI evaluation of the revised seventh grade curriculum, current plans are to have a select sample of eighth grade students who will also receive their instruction via CAI during 1968-69. The purpose and procedures for instructing this new group of students will be similar to those of the seventh grade: to gather response data for revising the instructional materials. Plans have not yet been made for the evaluation of ninth grade materials using CAI; however, it is possible that such an evaluation may be conducted beginning in the fall of 1969.

Planning is also underway to embed carefully designed test items into the seventh grade CAI instruction in the coming year. These test items will be based upon the behavioral objectives which are being established by the course authors. Each objective will be evaluated either through CAI-administered verbal items or, on occasion, through the manipulation of laboratory equipment. This criterion performance data will provide additional data for the succeeding revisions of the seventh grade materials.

C. CAI Behavioral Science Course For Social Welfare Students

Recent advances in the field of media and computer-assisted instruction have opened opportunities for professional education never before available. This new technical approach has particular significance for the social and behavioral sciences since research in these areas is resulting in quantities of data and facts that could be more effectively disseminated, mastered, and utilized by students via computer-assisted instruction.

In the spring of 1966, preliminary work was begun with graduate students in social work to determine the feasibility of programming behavioral science knowledge considered prerequisite in advanced social work education. The findings in a pilot prototype study in which 15 graduate students were given four different programs provided a positive indication of the feasibility of this approach. For the feasibility study, CAI programs were written in sociology, psychology, child development, and Freudian analytic concepts. Faculty members of appropriate departments in the University (Psychology, Sociology, Home and Family Life) were asked to review these programs. The changes, or corrections, and new directions that were recommended were incorporated into the programs that were used in the pilot prototype.

In September, 1967, the four CAI programs were further tested on 113 students who entered the graduate school of social work. The results of this further evaluative effort have encouraged the researchers to expand the effort into media simulation games and professional decision-making tasks. At this point, only the feasibility of developing curricula in the indicated areas of behavioral science has been established. The pilot prototype programs have not been tested for effectiveness with control groups. Further developmental research on these programs will help us produce a CAI behavioral science curriculum that may be generally useful to social work and other mental health disciplines.

The general goals of the proposed project are: To develop curricula in the human behavior and social environment sequence of social work, utilizing behavioral science knowledge to design a series of computer-based simulations to teach problem-solving and decision-making strategies. More specifically, the following objectives for curriculum development are to be met:

1. To construct a series of computer simulations using social work and mental health clinic situations.

2. To write a series of computer programs integrating computer programmed learning with video tape, continuous loop films, single concept films, or other visual aids.

3. To construct and test a series of computer simulations of clinical examinations, situations, and models to determine the usefulness of such simulations for students entering field placement in mental health clinics and hospitals.

4. To evaluate the effectiveness of the curricula designed by randomly assigning students to an experimental group using CAI and a control

group not using CAI. Appropriate research techniques would be employed to evaluate the placebo effect.

This project is quite ambitious in nature, given the requirement for social welfare situational simulation programs. We consider the need to evaluate and document the value and limits of computer-simulated professional decision-making and problem-solving to be high in the priorities of needed CAI research. Given the range of academic backgrounds and individual differences in academic proficiencies of the social welfare graduate students, we anticipate that a hierarchically organized set of simulation tasks will add significantly to the terminal competencies of the students.

D. Computer-Augmented Teacher Recruitment and Placement

All agencies of the educational enterprise have committed themselves to the fostering of excellence in the educational process via enlightened teacher recruitment and placement services. This is a proposed extension of the computer-based teacher placement project developed by Dr. William L. Maloy and James R. Swanson. (See the report in the results section.) The conceptions and plans for further developing this work form the substance of this report.

Three primary dimensions of technological approaches to improved teacher selection and placement can be clearly identified. The first of these relates to the breadth and type of communication. In essence, an office of teacher recruitment and placement not only plays a broker's role of bringing teacher candidates and local school district administrators together but, more importantly, providing the prerequisite and subsequent information by which these contacts can be maximized into effective job placements. The utilization of informational processing techniques should focus on the topic of providing relevant and personalized information in order to achieve the goal of appropriate teacher placement.

The second major dimension of needed development relates to the range and timing of the informational services. Via the use of informational processing techniques, one can anticipate a gradation of informational services that ranges from hourly requests to satisfy emergency teacher openings to semiannual requests to cover anticipated teacher positions. Perhaps more importantly, the nature of this informational service should be highly flexible in order to accommodate both the ease with which information about new positions comes into the general system and the appropriateness with which it is supplied to the candidate. The use of informational processing techniques is absolutely required in terms of the growing volume that currently has been identified.

The third major dimension of developmental need relates to the coordination of various educational agencies. A major first step would be coordination of our teacher-training institutions within the State of Florida in order to facilitate and foster the placement of highly qualified professionals into the local schools of the State. This coordination requirement will lead to an operational solution of the problem of compatibility of roles and information by the various school districts and agencies.

This communication should eventuate in the early identification and initiation of a dialogue between future teacher candidates and the potential teaching roles in the State of Florida. Thus, one objective is to develop the general information system in such a way as to provide appropriate, easy, and continuing contact with future teacher candidates.

Given the initiation of contacts from future as well as currently available teaching candidates, the general information system should be capable of providing appropriate teaching positions complete with accompanying information. As placements are made, appropriate reassignment of the candidate information should be accomplished in order to provide for eventual longitudinal studies regarding teacher effectiveness and stability.

The effectiveness of an improved communication process should eventuate in more appropriate matches between teacher candidates and the demographic and educational climate characteristics of given school situations. The intent of the informational system is to improve the decision-making process, both on the part of the teacher candidate as well as that of the school system. Consequently, a major objective will be the development of appropriate and relevant information to improve this decision-making process in teacher selection.

In order to effect this better communication, the informational system will have to depend on third-generation computer equipment that allows for real-time service. By real-time service, we explicitly mean the availability of near-instantaneous inquiries in order to satisfy emergency and unusual demands.

In addition, an appropriate gradation of inquiry and functions over time intervals that span all the way to projection studies appropriate for semiannual estimates of job openings. Thus, one objective will be to develop the information system so that queries can be made as to the availability of teaching candidates for specific job opportunities with appropriate characteristics. These requests can be made on a moment-by-moment basis. Secondly, a monthly service by which future candidates, currently available candidates, and school district personnel can be more adequately informed as to the developing job openings and human resource pools will be developed. Lastly, a corollary of this objective is the development of projection studies, with sufficient lead time, in order to estimate the availability of personnel to initiate the educational process in the fall and to continue it during the middle of the year. Thus, the speed of the communication process will be vastly improved.

As indicated above, the coordination of the efforts of teacher-training institutions and local school districts in effecting more adequate teacher placement is one of the major objectives of this project. This will require the investigation of mechanisms by which compatible and relevant information can both be received and disseminated to these various institutions. Over and above this, there is a need by which feedback can be supplied to the teacher-education institutions in order to more effectively adapt their programs with sufficient time, so as to meet the problems of education today and within the next few years. In this regard, a related objective will be the development of high utility information that would supply appropriate information to both the teacher-training institutions as well as local school districts as to such outcomes as the performance characteristics and ratings of teachers placed in local school districts. Secondly, studies will be performed as to the process by which teachers and local school districts go through the choice-making process. Moreover, school districts will want to analyze teacher mobility in order to more effectively stabilize their teaching population. In this regard, information dealing with candidates' qualifications, over and above that required for certification, will provide a useful source of information to school districts in regard to necessary in-service training. In turn, the teacher-training institutions will have a source of information for estimating future offerings. Thus, there is a whole host of evaluative studies which should eventuate out of an information system, specifically directed towards teacher recruitment and placement.

In summary, the following objectives for this project have been identified:

1. To develop the general information system in such a way as to provide appropriate, easy, and continuing contact with future teacher candidates.

2. To provide appropriate continuing communication between teaching candidates, the State Department of Education, and local school districts.

3. To develop appropriate and relevant information to improve this decision-making process in teacher selection.

4. To develop the information system so that queries can be made on (a) emergency moment's notice basis, (b) a monthly summary, and (c) a projection basis for predicting future personnel needs.

5. To expand the range and depth of information in order to improve the effectiveness of the recruitment process.

6. To study the utilization of this information to coordinate State agencies and institutions as well as to provide information to improve the in-service training and follow-up services for teachers.

This project will be initiated during the coming year. The techniques of project planning and management (PERT, etc.) will be employed.

E. Understanding and Utilizing the Concepts of "A Systems Approach" to Education Via Computer-Assisted Instruction: A Prerequisite to Implementing a Systems Model for In-Service Education

The "systems approach" to education has recently been proposed as an appropriate theoretical and methodological solution to many of the current challenges and problems in Florida education. While understanding that the "systems approach" has grown up within the context of the development of highly complex weaponry systems for the Department of Defense and has been utilized in the management of industrial and business concerns, its proposed application in education has led to both confusion and an array of negative reactions. In essence, the educator in many cases fails to see how systems concepts relate to his understanding of curriculum and instruction in a school setting or to see how systems analysis can facilitate supervision and improvement of the educational process. We propose to develop a set of learning materials which will allow administrators and leaders of education to better understand the nature and conception of systems analysis and modeling as they have applicability in the educational domain.

The immediacy of the need for understanding the "systems approach" to education is reflected in the Litton Report on a Systems Model for In-Service Education. For the administrator and supervisor in Florida, the suggested use of PERT, task analysis, and functional flow diagrams requires both a clear understanding of these conceptual tools as well as a degree of sophistication as to their potential utility. It is the contention of this proposal that prerequisite understanding of these concepts and related techniques in systems analysis will be required before the Litton Report can be implemented. Thus, we propose to develop a multi-purpose computer-assisted instruction course which would allow for a better understanding of how these systems management techniques can be usefully applied in Florida education.

The Litton Report and other related documents clearly demonstrate that educators in Florida are concerned about both methods and media applications, but have little personal acquaintanceship with some of their newer forms. The Litton Report indicates that less than three percent of the teachers in Florida have had any personal acquaintanceship with computer-assisted instruction. Moreover, the problem of individualization of instruction is seen only in terms of rate of progress, and rarely in terms of appropriate selection of content depending on individual levels of performance. Thus, we propose to present the course on systems concepts via computer-assisted instruction (CAI) so that each of the participant educators can gain personal experience about this new form of media and judge its relative merit as it might relate to the larger questions of appropriate media selection for the goals of education.

In the final analysis, the usage of systems concepts will ultimately come from their application in an educational, problematic context. It has been found that the use of simulated problems provides for operational experience with none of the consequent costs of mistaken judgments or lack of familiarity with the technique. We plan to utilize examples from problems dealing with media purchases and applications in Florida schools in order to teach analysis and problem-solving techniques to our participant educators. Thus, the CAI program will offer operational experience and competency to those who wish to use it.

Description of the Course. This CAI program will clearly indicate to the participating educator the flexibility and individual selectivity of CAI. Focusing on the topics of systems analysis and systems models, three levels of inquiry are proposed. The first can be thought of as a general introduction to and review of the major conceptions in the systems approach to education. Given a person who wishes to only be acquainted with the major conceptions and techniques, Level One offers a good systematic presentation and review.

Knowing that learners relate best to a meaningful context, we would propose a second level which would present many operational examples and specific utilizations of these concepts in the areas of elementary education, secondary education, and administration. Thus, a person wishing greater insight could pursue any given topic in Level Two within his own appropriate professional area. In this manner, the participant educator will have a chance to see how the systems management concepts relate to problems with which he is immediately acquainted.

The third level of inquiry relates to operational problem-solving. We propose to implement a series of simulated tasks that allows for the direct application of the systems concepts. Thus, for that educator who wants to become an actual practitioner of the "systems approach," he will have a chance to exercise his new found knowledge in a series of tasks that are hopefully completely analogous to current problems in Florida education. For example, an administrator might be required to analyze the purchasing and in-service training problem for a newer media device such as a concept film. Thus, Level Three offers a chance to consolidate the learning and apply the systems techniques. By utilizing CAI, each educator will be able to pursue the range of topics to his own self-determined depth. Thus, CAI allows for flexibility in course objectives and the opportunity to experience an instructional system while learning about instructional systems.

Objectives. In essence, this project will develop a CAI course that individualizes the approach to systems analysis and systems models in education. Specific objectives are as follows.

First, the essential concept of systems analysis and systems models to be acquired can be divided into the following eight subconceptual areas:

1. Management planning (analysis of management goals, manpower requirements and PERT charting)

2. Functional analysis (determination of context constraints, feasibility, and functional flow diagramming)

3. Behavioral goals (determination of levels of behavioral performance and relations to task performance)

4. Instructional strategies (determination of appropriate instructional learning pathways to accomplish the projected goals)

5. Media selection (selection of appropriate instructional media in order to implement the instructional strategies)

6. Activity analysis (consideration of the overall activity in order to determine operational procedures)

7. Systems specification (determination of appropriate manpower and equipment requirements)

8. Evaluation and final design synthesis (determination of revision cycle and potential growth for an educational project).

The primary objective will be to effectively teach these concepts.

Each of these concepts will be prepared in order to allow for three levels of inquiry, namely: (a) a general understanding; (b) specific relationships to a specialized area of education; and (c) operational problem-solving. There will be a heavy stress on the relationship of the "systems approach" to ultimate development of new programs for in-service education.

An additional objective will be the determination of the effectiveness of this CAI approach to teaching systems concepts as well as its concurrent effect on positive and negative attitudes towards technological techniques of instruction.

F. CAI Systems Programming

The delivery of a new CAI hardware and software system, like the IBM 1500 system, requires considerable extension of the manufacturer's programming package in order to accomplish research goals as well as to provide an efficient, flexible operation. As described in our July, 1967 Semiannual Report, we contend that a generalized data management system is required for even preliminary data analysis.

The major goal of our developing data management system (which is a series of flexible, interlinked data manipulation and statistical analyses programs) is to provide the researcher with his specified data analyses reports that will foster extensions, course revisions, and hypothesis testing derived from his CAI program. In essence, the data management system should provide complete internal manipulation of data (i.e., no required output/input of data such as by cards) while efficiently handling the logistics of multiple research endeavors and the open-ended growth of the response history file structure.

Instead of reviewing the architecture of our data management system, we include a concise description of current computer programs. The status of each program is either (1) completed (i.e., operative without any known errors), (2) testing (i.e., coded but requiring more error checking), or (3) designed (i.e., planned and specified via flow diagrams and functional requirements).

In the section under data management, the programs relating to the condensing, editing, and manipulation of the learners' history files are presented. The section on CAI computer programs and special functions enumerates the programs that provide for extensions of the COURSEWRITER II operating system. The third section on utility programs presents the necessary input/output routines for efficient use of the computing equipment. The fourth section presents a list of miscellaneous programs found necessary in order to further our development of both the CAI operating system as well as the data management system.

A. DATA MANAGEMENT: These data analyses preparation programs convert CAI response records produced by students into a workable file structure.

1. Conversion and Edit.--This program converts variable length raw records to fixed length history file records. (Status: completed)

2. Merge.--This program merges sorted updated CAI response tapes to history file master reels. (Status: completed)

3. Sort.--This program sorts condensed CAI responses by course name by student. (Status: completed)

4. Delete/Select.--This program deletes or selects specified CAI responses from master history file. (Status: testing)

5. I/R Monitor.--This monitor system controls and schedules all of the data management programs. (Status: completed)

6. Curpa.--This program pulls specified CAI responses from history file and builds an output tape. (Status: completed)

7. 1130 Statistical Package.--This program package (multivariate analyses, regression models, and correlation techniques) is adapted to the 1800 system. Statistical programs are to operate on master response file data. (Status: completed)

B. CAI CONTROL PROGRAMS AND SPECIAL FUNCTIONS: These programs are written to be used in CAI mode.

1. Location.--This command is used in proctor mode to locate specific labels and to give their relative disk addresses. (Status: completed)

2. Reloct.--This background application is used to move a CAI file from one pack to another. It also updates all linkages. (Status: completed)

3. Help.--This command is used in student mode. It will allow a student to go from one label to another. (Status: testing)

C. UTILITIES PROGRAMS: These are general utility programs that allow for more efficient system operation and data management.

1. Tape to cards
2. Tape to printer
3. Tape to cards and printer
4. Tape to tape
5. Tape to disk
6. Cards to tape

7. Disk to cards

8. Disk to printer

9. Disk to cards and printer

10. Disk to disk

11. Cards to disk

12. Disk to tape

13. 80/80 reproduce

14. 80/80 list.

(Status: completed)

D. MISCELLANEOUS PROGRAMS: Below is a list of these programs and what they do:

1. MAGTI.--This program allows building and manipulation of unlimited array sizes in FORTRAN and Assembler language. (Status: completed)

2. MAGT.--This program allows end of reel to be recognized. This is a modification of IBM-supplied I/O routine. (Status: completed)

3. EBIN.--This program converts EBCDIC to binary. (Status: completed)

4. BINE.--This program converts binary to EBCDIC. (Status: completed)

5. LCAL.--This program calls programs from TSX pack by program number and loads it into core. (Status: completed)

6. TAPE TEST.--This program reads tape and dumps records with errors. (Status: completed)

7. SPLIT TAPE.--This program splits an input reel into two output reels. (Status: completed)

8. PRHEX.--This program prints tape in hex. (Status: completed)

9. SEQ.--This program punches sequence numbers in cards (cc. 73-80). (Status: completed)

10. MOVE.--This program moves one area of core to another. (Status: completed)

11. VDMTP.--This program dumps variable length tape records. (Status: completed)

12. ABSTRACT.--This program aids in program documentation. (Status: designing)

III. PLANNED STUDIES OF COMPUTER APPLICATIONS IN INSTRUCTIONAL AND ADMINISTRATIVE PROCESSES

A. A Comparison of the Effects of Computer-Assisted Instruction and Lecture-Discussion Methods of Presentation in a General Curriculum Class

William Lee Proctor

This study involved the comparison of three modes of instruction: (1) lecture-discussion, (2) computer assisted instruction--linearly sequenced, and (3) computer assisted instruction--student sequenced. The sequence of the linear program is predetermined, in that the student exerts no control over the sequence in which the various concepts are presented. The student sequenced CAI program is designed to permit the student to select his own path through the material. In addition, this latter presentation will allow the student to recycle through the various subsections of the course.

The subject matter taught during the experiment was selected from an education course pertaining to curriculum development in elementary and secondary schools. The CAI programs were taught via the IBM 1500 system. The investigator served as instructor for the lecture-discussion group, and all class sessions were tape-recorded.

Variables investigated included learning acquisition, retention, instructional time, attitude, and essay test performance. Student response records also permit an analysis of the extent to which students in the self-selection of sequence treatment deviate from the linear format.

Preliminary analysis of results indicates that the CAI-student sequenced group performed best on both the post and retention tests. This group also reflected the highest positive attitude toward the method of instruction employed. At this point, the statistical significance of the results has not been ascertained.

B. An Investigation of the Application of Computer Assisted Instruction and Information Retrieval Systems to Academic Advising in a Junior College

Harry V. Smith

This is a study of the application of Computer-Assisted Instruction merged with a process of information retrieval to the problem of academic advising of junior college students. The study will investigate four areas: (1) information suitable for inclusion in an automated advisory program will be determined by interviewing both students and faculty advisors, (2) a program for the automation of certain aspects of the advising function will be designed and implemented, (3) the efficiency of the student-machine interaction will be studied, and (4) the adequacy of the automated system will be evaluated.

The evaluation will be on the basis of the following operationally defined criteria:

1. Acceptability.--The students' attitude toward the automated process is not significantly less than their attitude toward the human advisor.

2. Worthwhileness.--The attitude of a faculty jury toward the automated process is not significantly less than their attitude toward a human advisor.

3. Systems adequacy.--The number of faculty jury requests for relevant information which cannot be incorporated in the systems program, will not be significant.

4. Systems efficiency.--The number of trouble signals on the part of the student and/or the number of sign-offs due to equipment failure will not be significant.

The primary aim of this study is to provide a method of information retrieval from a student record and course description data base, and to merge it with a CAI program which provides a logical dialogue, in order to automate and simulate certain aspects of the human advising function, and to demonstrate that such a system is worthwhile, as defined herein, in an operational sense and acceptable, as defined herein, in a human factors sense.

The developmental sample will consist of ten students and ten faculty advisors from Tallahassee Junior College (selected by the chief counselor) and will be questioned in tape-recorded interviews to determine the information to be placed in the automated system. After the interviews are completed, the information on the tapes will be listed and tabulated. An attempt will be made to include in the automated system all information which is requested by two or more students or advisors.

A record which includes information such as students' I.D. and grades for completed college courses will be stored on the systems disk and will be the key for the logic flow and retrieval. Codes retrieved from the student record will be used to branch the student to that portion of the CAI program related to his academic goal.

After the systems program is complete and operational, the author, a faculty advisor, and a student will trace all branches of the program in order to debug it.

A selected sample of 50 students will be chosen to participate in the study. All responses by the students during the dialogue will be written on disk and will be available for later analysis. A jury of six academic advisors will interact with the system as though they were students, and, along with the student population, will complete an attitude questionnaire designed to assess the adequacy and acceptability of the system. A detailed analysis will also be made of the nature and quality of the students' questions which are not satisfactorily answered by the automated system.

C; The Interaction of Examiner Attitude with Praise and Blame.

Ted M. Wilson

Praise and blame have been found to be stable and effective reinforcers in the acquisition of motor skills (Kennedy & Willcutt, 1964). It has also been found that the effect of these variables may be greatly altered by the examiner's characteristics such as race and attitude (Allen, et al., 1966; Kennedy & Vega, 1965; Kirschenbaum, 1962).

In the present study, an IBM 1500 Computer-Assisted Instruction (CAI) system was employed to standardize the administration of praise and blame and to control the examiner's attitude as conveyed to the Ss.

One hundred and twenty-eight university sophomore and junior psychology students were subdivided into 16 groups of 8 Ss each. Two sets of 16 oddity discrimination problems were utilized to assess the effectiveness of four levels of verbal incentive (praise, blame, neutral statement, nothing), and four CAI examiner attitudes (positive, negative, neutral, nothing). All combinations of incentive and attitude were employed. An attitude statement randomly accompanied 8 of the initial 16 problems. A verbal incentive statement was then displayed to the student. This was followed by the representation of the 16 oddity problems. Response latencies, errors, and posttest attitudes toward CAI functioned as dependent variables.

Although the data analysis for this study is incomplete at the present time, it is hypothesized that positive examiner attitudes will enhance the effect of praise, and that negative attitudes will retard them. The converse is predicted for the influence of blame.

IV. INDIVIDUAL AND GROUP DIFFERENCES IN LEARNING UNDER TWO DIFFERENT MODES OF COMPUTER-ASSISTED INSTRUCTION

Aaron Bauldree

The purposes of this study were (a) to determine if two CAI macro-adaptive instructional strategies would produce differential mean achievement and (b) to investigate possible learner-variable by instructional strategy interactions which might occur for two different macro-adaptive approaches. The first strategy consisted primarily of a series of multiple choice test questions related to the class text. The second macro-adaptive approach consisted of a series of lecture-like presentations.

Fifteen Guilford-type ability factors thought to be relevant to success in either one or both of the instructional strategies were rank ordered by twenty-six pre-trained judges according to their relevance for predicting success in each of the instructional strategies. Seven factors were rated in the top five categories for one or both instructional strategies. A battery of eight tests measuring the seven factors was administered to ninety-five Florida State University students who were enrolled in courses in which the instructional materials utilized in the investigation could be made a regular part of the instructional process.

Students were randomly assigned to treatment groups. Each student was given the equivalent of three class periods of instruction; that is, each student was given the regular textbook reading assignment and then, rather than reporting to the classroom for the customary lecture, he reported to the CAI Center for individual presentation of the learning materials. After the three periods of instruction by CAI, all students returned to the classroom for a posttest designed to measure acheivement in the CAI sessions.

TABLE I

THE 8 FACTOR ABILITY TEST AND THEIR RESPECTIVE CODES AND FACTORS

Tests	Factors
1. Sentence Order (o3b)	Convergent Production-Semantic Systems (NMS)
2. Memory for Word Classes (o4A)	Memory-Symbolic-Classes (MSC)
3. Addition Test (N-1)	Memory-Symbolic-Implications (MSI)
4. Division Test (N-2)	Memory-Symbolic-Implications (MSI)
5. Wide Range Vocabulary Test (V-3)	Cognition-Semantic-Units (CMU)
6. Object-Number Test (Ma-2)	Memory-Symbolic-Relations (MSR)
7. Necessary Arithmetic Operations (R-4)	Cognition-Semantic-Systems (CMS)
8. Hidden Patterns Test (cf-2)	Convergent Production-Figural-Transformations (NFT)

Mean differences for the two macro-adaptive instructional strategy groups were determined for (1) each of the eight ability factor tests, (2) achievement at each of three different stages of learning, (3) time spent reading textbook assignments and (4) time spent on CAI. No significant group differences were obtained for any of these variables. Thus, one could conclude that different instructional strategies lead to the same level of group performance on criterion measures. The situation with respect to individual performance and the aptitude-treatment interaction is more difficult to interpret.

Differences between individual simple regression coefficients for each instructional strategy group relative to each ability factor were computed. The results show that six of the seven ability factors used in the study produced significant interactions at some point during the learning period. The six factors which produced interactions are Cognition-Semantic-Units (CMU), Cognition-Semantic-Systems (CMS), Memory-Symbolic-Relations (MSR), Memory-Symbolic-Implications (MSI), Convergent Production-Semantic Systems (NMS), and Convergent Production-Figural-Transformations (NFT). However, factor CMU was the only factor that produced consistent results throughout the entire experiment. The failure of the other factors to produce consistent results might be attributed to a change in the ability factor pattern that could be used to predict success at different stages of learning as reported by Fleishman (1957). If this is the case, guidelines for adapting instruction to individual differences can be established only by studies that extend over the entire period of instruction for which achievement is to be predicted.

Correlations between amount of time spend reading textbook assignments and achievement were negative and significant for Group I. For Group II, the correlations tended to be negative but were not significant.

Correlations between amount of time spent on CAI for Group I were close to zero, not significant and tended to be negative. For Group II, the correlations were negative and significant.

Thus, it appears that low achieving students in Group I spent more time with textbooks than did high achieving students. In Group II, the high achieving students spent less time on CAI than did the low achieving students. Both of these conclusions are due in part to the actual instructional strategies involved.

In summary, the following findings resulted from the experiment:

1. The mean differences for achievement of the two groups were not significantly different.

2. Six of the seven factors produced significant interations at some point during the learning period.

3. The only factor which produced consistent results throughout the entire learning period was the Cognition-Semantic Units (CMU) factor.

4. Correlations between time spent reading textbook assignments and achievement and time spent on CAI and achievement indicated that the diagnostic practice instructional strategy stimulated more textbook reading among low achieving students than did the programmed lecture strategy.

CURRICULUM EVALUATION VIA CAI FOR THE INTERMEDIATE SCIENCE CURRICULUM STUDY[1]

Walter Dick

Florida State University

ISCS, the Intermediate Science Curriculum Study, is a project devoted to the development of a self-paced, process-oriented set of science curriculum materials for use in seventh, eighth, and ninth grade classrooms. The project is directed by Dr. Ernest Burkman, and is staffed primarily by faculty members from the Department of Science Education at Florida State University. This resident staff is joined annually by a summer writing team of subject matter specialists. The immediate goals of the project are to develop a rationale and a set of specific objectives for science instruction, to write the instructional materials, and to study the impact of these materials on a national sample of junior high school students. An additional goal of the project team is to use these instructional materials in long-term research studies which will be conducted in classroom settings.

During the summer of 1966, the materials for the seventh grade were written and, subsequently, evaluated during the following winter. During this past summer, the seventh grade materials were revised, and the initial set of eighth grade materials was developed. Next summer,

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[1]Paper presented at the American Educational Research Association meeting, Chicago, Illinois, February, 1968.

materials will be prepared for the ninth grade. Two methods have been, and are being, employed to evaluate these materials: large-scale field testing and computer-assisted instruction. Approximately 5,000 students and 50 teachers used the materials in various schools around the country last year, while over 11,000 students and 100 teachers are using them this year. The CAI evaluation has been conducted with 16 students during both years.

What *is* the rationale for the use of CAI as a curriculum evaluation tool? Perhaps the *outcomes* of both CAI and large-scale field test evaluations can best be described in terms of two, somewhat overlapping circles. Both types of evaluation provide general measures of the effectiveness of instruction and an indication of the more noticeable rough spots in the materials. Field studies provide, in addition, information on the logistics of implementing new materials and management problems encountered by a large number of teachers. In addition, they provide demonstration centers in which other teachers and administrators may view the materials in use in the classroom. The unique contribution which CAI is now making to curriculum evaluation is that, for the first time, fine-grained data can be obtained during the formative development of a curriculum; data which can be utilized to improve the instructional materials. It provides information on the learning difficulties of the individual student as he is sequenced through the learning materials. This data can also be sorted in such a way that group performance on particular concepts can be investigated.

Therefore, because of the ISCS interest in the evaluation of their instructional materials via CAI, a joint project was established with the CAI Center. We, in the Center, have three major interests in this project which may best be stated in the form of questions:

(1) What are the procedural requirements for successfully implementing an entire year's curriculum in a given area?

(2) Will a generalized data management system provide data which can be effectively used by curriculum writers?

(3) What is the actual cost of this type of evaluation?

The remainder of this paper will be addressed to these three questions.

In order to obtain the evaluation data, the seventh grade text, which is being used in the classroom, has been prepared by the ISCS staff for CAI presentation following essentially a programmed instruction, linear format. The course also includes numerous excursions to which students are branched for both remedial and enrichment instruction. Every effort has been made to simulate CAI learning experiences similar to those which other students are experiencing in the classroom, and therefore feedback is provided to the CAI student only when similar feedback would have been provided if he were studying the regular instructional materials.

The students who are serving as subjects in this project have been carefully selected from the seventh grade of the Florida State University School in which the ISCS materials are concurrently in use. These students represent, in terms of a measure such as I.Q., a range of abilities which is likely to be found in most seventh grade science classrooms. The I.Q. range of this year's students is 85 to 135.

Rather than receiving the ISCS materials in their regular classroom, these selected students come each morning to the CAI Center and progress at their own rate through the learning materials. Since laboratory experiments form an integral part of the ISCS approach, the students are directed, by their program, to go to the laboratory area within the CAI Center, to carry out these activities. When they return to their terminals, they are asked questions about the experiment, and are required to submit the data which they have obtained.

There is a graduate instructor with the students at all times when they are in the Center. It is his function, as he simulates the role of the classroom teacher, to encourage the students to arrive at their own solutions to the inevitable questions which arise. Only as a last resort does he lend direct assistance. The documentation of student problems by the instructor and how these problems are solved are a valuable supplement to the response data. The proctor comments are now entered immediately and directly into the computer system and are available for retrieval later.

Although the major purpose of this CAI activity is to gather data for the revision of the instructional materials, it is obvious that some comparative analysis of the performance of CAI versus ISCS classroom students was required. Several times during the past academic year and, continuing this year, similar tests have been given to all the ISCS students in the University School and in the CAI Center. There has been no significant difference in the performance of the two groups. In addition, none of the students have requested to be transferred from the CAI group back to their classroom. In fact, following approximately 120 hours of instruction last year, the students were still quite enthusiastic about their experiences. Their responses to a questionnaire further reflect this very positive attitude.

We at the CAI Center, therefore, feel that the answer to our first question is, "Yes, we have evolved an understanding of the procedural requirements for implementing an already existing set of materials on our CAI system."

Our second question dealt with the feasibility and acceptability of a generalized data management system. One of the major projects over the past two years in our Center has been the development of a series of programs which would form a system for reducing and analyzing the thousands of student responses which are recorded on magnetic tape. It is one thing to develop programs which satisfy the needs of one or two in-house projects, and quite another to develop a system which will produce satisfactory data formats for all users.

The basic record which is written each time the student responds to a question on our 1500 system includes, among other things, student and course identification, date, programmer-generated identifiers of the question which is asked and the response which is made by the student, response latency, and the numerical values of all the counters and switches. Very briefly, our data management programming system first reduces and compacts these recordings. It then sorts out the responses by each student within each course. This is done on a daily basis. Periodically, these sorted tapes are merged into a student history file. This file, therefore, contains the responses of all students to all items to that date. At this point, the file can either be printed, which would indicate the path of each student through the material, or it can be sorted further by item. Our print-out of this item sort is in the form of a summary table which includes the number and percent of the students who match each response option for each item. It also indicates the median latency for each group of responses and the standard deviation. This is the type of information which was provided to the ISCS staff. An additional program produced a matrix of student-by-question responses which indicated the general pattern of answers. Student-generated, schematic diagrams and data tables, as well as proctor comments, were also provided. All of this information was integrated by the ISCS staff and, subsequently, provided to the summer writing team.

This information was used to a certain extent by the summer writing team, but their general comments indicated that there was too much information, that it should be more highly summarized. They further indicated the desire to be able to easily locate and cross-reference data on concepts that appear in a number of locations in the materials.

On the basis of this experience, we went back to the drawing board this past fall. The system which we had developed was necessary, but not sufficient for the specific needs of ISCS. Two major changes have been made to date. The first has been to add a select-and-delete capability to our data management system for clustering item information. This can best be understood in terms of the item or question identification procedures. The programmer can label these items in any way he sees fit, within certain restrictions. The ISCS staff has coded all of their items with respect to their content; for example, work, speed, light energy, etc., and with respect to the process involved in the item; for example, operations with decimal numbers, hypothesis formation, making observations, etc. With these label identifiers, it is now possible to use the select function in order to extract the summarized item data covering specific topics or processes which occur in a variety of locations in the instructional materials. Using this same technique, it is also possible to select out those items which had median response latencies of greater than some number of seconds or those items which were correctly answered by less than some given percentage.

The second major change has been the decision that the data reduction and summarization beyond that already described, will be carried out by the resident staff of the ISCS project and not the members of the summer writing team. On the basis of this and other projects, it seems unlikely that subject-matter specialists will ever be willing, or have the inclination, to scan vast amounts of data and then rewrite their materials on the basis of this information. Therefore, the ISCS staff will now be responsible for the task of converting the selected item and student data into sound recommendations for material revision. If the need arises, the data will be available to back up such recommendations but it will not simply sit unused on the writer's desk.

Our answer to the second question which related to the viability of a generalized data management system must be one of restrained optimism. The development of such a system is obviously an evolutionary process which should become more and more refined with each succeeding interaction between the data and user.

Our final question relates to the costs of this type of CAI evaluation. Everyone is conscious of the current, rather tight fiscal situation. No one is more aware of this condition than the users of stand-alone CAI systems. We have been required, by our University, to establish the rates for the use of our CAI equipment based upon the same type of procedures which are recommended by the Federal Government for usage by conventional, batch-processing computer centers.

In order to generate the costs for implementing the ISCS project materials, we have not simply multiplied our systems rental cost by the percentage of usage time chargeable to ISCS, but have included such items as unit record equipment rental charges, laboratory remodeling costs for accommodating our new equipment, maintenance and janitorial services, certain portions of faculty and staff salaries, general office expenses, and computer supplies.

The total costs for the ISCS project, therefore, reflect all of these items as they enter into our charges for both the central processing unit and terminal usage. In addition, the costs of the three graduate assistants, a coder who enters the materials into the system, and one-fifth of a faculty member's time have also been added.

The sum of these charges for the current nine-month phase of the project, using the 1500 system, is $34,865. It is of interest to note that this figure of approximately $35,000 represents a cost of about $12 per instructional hour. However, only $2.13 of that $12 goes for student terminal time usage. The remainder covers the cost of material preparation, proctoring, and data reduction. These figures should, in no way, be construed as an argument for the economic feasibility of placing CAI terminals in all our schools. The field is a long way from the $.40 per classroom hour that we purportedly now spend on our children. The costs are intended to show that CAI does provide a rather economical and feasible approach to the gathering of fine-grain evaluation data. The term "economical" is used to refer to the fact that only a small percentage of the funds usually required for a large field study could be diverted in order to provide a CAI-based evaluation. One can also expect that, after two or three cycles through this process, there will exist not only a much evaluated and revised set of classroom instructional materials, but also, as a by-product, a quite reasonable CAI instructional program.

COMPUTER ASSISTED INSTRUCTION

IN SOCIAL WORK*

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COMPUTER ASSISTED INSTRUCTION, TECHNOLOGY AND VALUE

The old cliche - "there is nothing new under the sun" - needs revision. There is something new called computer assisted instruction and educators, ready or not, will have to learn this new technology and its terminology. Computer assisted instruction is also known as computer based instruction and computer augmented learning. Whether you use the letters CAI, CBI or CAL you are talking about essentially the same thing, the use of a computer to handle some of the elements of teaching. The word <u>some</u> is used because most specialists in this area do not see the computer as ever replacing the teacher either at the grade school, undergraduate or graduate levels of education. Instead, it seems to be generally agreed that certain functions may be safely assigned to a computer, e.g. it may serve as an excellent way to instruct in terminology, to give extensive practice in basic skills, and to teach problem solving.[1]

[1] Duncan N. Hansen. Computer-Assisted Instruction at Florida State University, Tallahassee, 1967, p. 5. (Mimeographed)

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Technically what we have in the computer is a mechanized tutor capable of confronting the student on a one to one basis, a goal that may have been achieved in the case of Mark Hopkins on one end of a log and the student on the other. The tutorial relationship is rather rare in modern education; instead we find ourselves teaching larger and larger classes. In some of our universities classes of 1,000 students meeting in a large auditorium for a lecture in elementary psychology or sociology are not unknown. In graduate education we have the expectation, if not always the reality, that we will have some small seminars but a goal of tutoring students is outside our reach. The computer changes all that and offers the possibility of endless and tireless tutoring. Using CAI, a question may be asked of the student, and a variety of possible responses may be programed. The instructor allows for the correct response or the sought after response, but allows for interaction also with the student giving partial or incorrect responses.

The infinite patience of the machine then may be utilized by the instructor to do the chore work of endless repetition and discussion until the desired learning has taken place. Instruction in terminology is, as previously stated, an excellent use of the computer, but what about practice in basic skills and problem-solving? Here the creative possibilities of using the computer to simulate situations needs description. The capacity of the computer to store in its magnetic memory millions of characters, groups of which may be used to form programs, permits us to devise simulations of actual situations while allowing for a wide variety of exceptions to be posed for the student. These exceptions can be incorporated into a problem-solving and decision-making matrix. As in the games strategy and gaming techniques the student is confronted with facts and with choices. His selection of the right or wrong answer is immediately confirmed making the learning process a dynamic current experience. Although much more could be said relative to CAI capabilities from the technical standpoint, two more advantages ought to be mentioned. One, that CAI is basically programed instruction with the added capabilities of a CAI system to immediately evaluate student responses automatically, something not possible with a textbook or teaching machine. Two, the student may be branched into learning programs instantaneously by a computer decision based on the cumulative records being kept on the student's progress. In the latter case it is possible for the instructor or author of a program to set up a series of counters which check student's failure rate, and at some previously decided critical point branch the student to additional learning material or recommend that the student review certain readings or even come back at a later time and take a prescribed learning program.

From the instructor's point of view then the computer may be seen as a tool, just as a book is a tool, which he may use as a willing slave.

The instructor may then be available to students for the intellectual jousting which is so much more important but often is neglected because time is simply not available. We may also pose the question of whether the educator using the computer instruction capabilities might then be released to do the thinking and writing so important to the academic community.

COMPUTER ASSISTED INSTRUCTION AT FLORIDA STATE UNIVERSITY

Research and development of computer based instruction was begun at Florida State University in 1964 by the Institute of Human Learning. The research led to the establishing of a computer assisted instruction center on the FSU campus which went into operation April of 1965 doing research on the prospects of CAI and developing programed materials for instructional purposes.[2] An introductory course in collegiate physics, applied statistics, computer languages, chemistry, basic reading and mathematics for adults are examples of some of the CAI courses offered in addition to the social work basic concepts course to be described in detail later.

In operation at the center are two computer systems, the IBM 1440 and the IBM 1500. The IBM 1440 system components are, a processing control unit, three disk memory units, a magnetic tape unit, a console,

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[2] Duncan N. Hansen, *Ibid.* p. 1.

a card read/punch device, a printer and a data communications system. The last item provides input and output by means of the 1050 which resembles and works like a typewriter. This system also allows for random access slide projection and random access tape recording equipment. Students and authors enter and receive information within the Central Processing Unit by using the 1050 terminal.

In September 1967, the CAI Center added a new computer, the IBM 1500 which essentially is the same as the IBM 1440 but with a video screen similar to a television screen and with a light pencil attached. Students see an entire question and the choices of possible answers. Using the light pencil attached to the terminal, the student marks his answer and immediately is advised as to the correctness of his choice. The IBM 1500 therefore is a much faster machine than the IBM 1440 which types out all instructions and responses. Both machines, however, have their advantages and disadvantages and should be used selectively according to the need.

RATIONALE FOR CAI PROGRAMS IN SOCIAL WORK

In the spring of 1966 preliminary work was begun with fifteen graduate social work students at FSU to determine the feasibility of computer presentations of behavioral science knowledge considered prerequisite to advanced social work education. For the feasibility study, programs were written in sociology, psychology, child development, and Freudian analytic concepts. Faculty members of the University, (Psychology, Sociology, and Home and Family Life) were asked to review the programs, to suggest changes or corrections, and to recommend new directions if necessary. The resulting programs were the ones used in the feasibility study.

The interest and enthusiasm of the first fifteen students for the CAI programs was enough to suggest further exploration. The fact that the students were volunteers in the pilot program and therefore were singled out for special attention was considered to have had a possible "Hawthorne Effect" in respect to the expressed interest and enthusiasm. However evidence of learning was strong enough to warrant a larger evaluative effort which was undertaken in September 1967 with 113 members of the first year class.

Feasibility having been tentatively established, the second evaluative effort had as its objective the use of the four programs as screening or diagnostic devices for the development of student profiles. A second part of the objective was to lead students weak in any of the four programs through a learning program or learning loop especially designed to strengthen their basic knowledge. Material for the four programs in psychology, sociology, child development and Freudian concepts was selected on the basis that (1) social work requires a basic background in the behavioral sciences, and (2) that although no consensus exists regarding specific content prerequisite to professional training yet there is enough agreement in what we assume students should bring with them in the way of academic background so that we can at least select the areas of knowledge to be tested. At this point in the research the test questions have not been validated with control groups since this is projected for the next step, but they do seem to offer a reasonable approach to the question: What do students need to know upon entrance into a graduate school of social work?

The fact that students come from a wide variety of academic backgrounds makes it even more imperative that we do not assume that students have had adequate preparation enabling them to understand basic concepts and terminology of our first year graduate social work courses. This fact presents us with a challenge which might be met with pencil and paper tests. However such tests lack the kind of immediate feedback for student and teacher possible in computer assisted instruction. But, even more important than testing the student is the necessity to institute immediate remedial work in his area of weakness. This of course can be done instantaneously in CAI and offered the final compelling reason for experimenting with CAI programing. Additionally, this reason satisfied the question of, "Why one more testing program for students already accepted into graduate social work?" with the answer that students using CAI can be assisted in a meaningful way to an understanding of curriculum content necessary for rapid advancement during the first eight weeks of graduate school.

RESEARCH DESIGN AND DISCUSSION OF FINDINGS

This second evaluative effort (labeled Phase II) involved 113 first year graduate students entering social work in September 1967. Taking the CAI program was made mandatory for every member and only one blind student with a ninety per cent visual handicap was excused. The rationale for this action was to determine total student reaction to computer assisted instruction. Phase III which will begin September of 1968 will involve a fifty-fifty split of that first year class into experimental and control groups. Assignments to either group will be made using a table of random numbers. A post test of the two groups will then be conducted to ascertain possible differences between students taking or not taking computer assisted instruction.

The procedures for the September 1967 testing were rather simple. A list of all first year students with their student numbers was given to the CAI center. Students phoned the center and made their own appointments based on their available time and also availability of terminals to the computer.

Each of the programs in the four areas of knowledge mentioned was designed to be between one to one-and-a half hours long. The intent here was not to tire the student which might be reflected then in poor responses. If time was available and the student worked fast it was thought that some students might go on to a second program. This in fact was exactly what did happen.

Each of the four programs was designed with a test section which was given first. If the student did poorly in any area he was expected to take the learning program, which in essence went back over the same material but this time gave the student information which made it possible for him to learn the necessary facts about the subject, and to answer the questions correctly. The intent here was to design tests which would reveal student weaknesses in the four selected areas, and then allow for remedial work using CAI in order to bring the student up to a level presumed necessary to understand beginning social work terminology and concepts.

The programs, although designed to be given to all students, allow for both privacy and individual differences. Each student works at a typewriter-like terminal which in appearance and operation is similar to an electric typewriter, and in a separate cubicle housing the terminal, a desk and a chair. Each room is also equipped with a buzzer system to call the proctor who is always present to offer assistance in the operation of the terminal or to handle technical problems. In order to avoid a completely impersonal atmosphere the programs were written with a touch of humor and at strategic places the computer asks the student to, "Think of me as George."

The first time this remark shows up on the printed page students are a little surprised but they do like the idea of the human touch and often, in later class discussions will preface a statement with "George said..." This is usually good for a laugh from the rest of the class. In fact, since the entire CAI program in social work is called CONSOWEL (short for Concepts in Social Welfare) the name George Consowel has been suggested and is under serious consideration for Mr. George Computer! Students can also rid themselves of some hostility at times when they can personalize the computer.

The feeling of individual instruction is made possible by the nature of the typewriter terminal and the computerized programing. The student has the statements and questions printed automatically by the typewriter. Likewise, his own responses as they are typed become a part of the record. A question answered incorrectly or with an unfamiliar response can later be examined by the instructor, who, on the basis of a review of the question may want to add the student's answer as an acceptable one, or it may even cause the instructor to revise the question. The student's copy of the material, called a "Print Out" is his to take with him and review at some later date.

In order to further individualize the instruction the research design called for "counters" to be inserted after each question so that students would know at the end of each program how well they had done. For those receiving high scores the statement on the printout said, "Great, your responses indicate a good background in the area of psychology (or whatever subject) and you should not have any difficulty with this area of your social work studies." Other students whose count of incorrect answers was high, received a statement directing them to take a learning program in psychology (or whatever) and to make an appointment at the front desk for this additional CAI material. It should be noted here that in using computer assisted instruction strictly in the instructional mode (not testing) it is possible to branch a student to a review of material or further explanation of concepts immediately, without needing to make appointments to take further instruction. However, since Phase II was designed as diagnostic, a different approach had to be used.

The final component in this design was to request from the computer a response report on each student so that a detailed examination could be made of every response of the 113 students. From this set of analysis sheets, one could theoretically profile students' responses individually or collectively against any known mean derived from the questions in these programs.

FINDINGS

The results of the second evaluative study have produced a number of observations which are listed below. The nature of the evaluation to date has been observational and although no numerical count was attempted, in general, students reported that they "enjoyed," "were interested," or "intrigued" by the CAI programs. Most claimed that they "learned a lot," or that "the review was very helpful." Many claimed that the review factor alone was worth the time it took to complete the programs. Other faculty members reported that students would quote from the CONSOWEL programs citing CONSOWEL as their reference on a particular point. Students reported that they seemed to remember facts that were reinforced in the programs.

Perhaps predictably, the better students seemed more enthusiastic, completed the programs early and were anxious to discuss various questions which had occurred to them. The weaker students were more fearful, resisted making appointments and found excuses for delaying completion.

One surprise was to find that women students were much slower in getting started on the programs, claimed they were "busy" or "not used to machinery" or whatever. At any rate the women students responded slowly out of some fear of failure or discomfort. After completion however most of the women admitted that their fears had been groundless and that in fact they enjoyed taking the programs. Only one woman student was willing to admit that she "hated machinery," "didn't know how to type" and felt uncomfortable throughout.

In general, the findings showed that (1) the programs were well received, (2) the students were interested enough to raise questions, (3) they remembered items in the programs well enough to cite them in class, and (4) the students reported having learned.

DISCUSSION

The first part of the objective for Phase II--to use the CAI programs for screening or diagnosis--was successful. Students were enabled to see their strengths or weaknesses as a result of taking the programs. The student profile component of the objective, however, was not included this time due to programing problems and the fact that "counters" were not inserted so that a quick profile could be established immediately upon program completion. However, this lack did not invalidate the profile concept. Response print-outs on each student were made, but these are not immediately available either to the student or the instructor. These print-outs are cumbersome and analysis is slow because of the sheer amount of data. Print-outs, for example, for the 113 students resulted in a pile of paper three feet high. The answer to this problem is to insert counters and ask only for the number right or wrong and the percentages in each area.

The response print-out does serve an important function in another area; that is, the testing of the curriculum content. Statements misunderstood, or questions answered incorrectly two and three times by a sufficiently large number of students, indicates ambiguity, poor wording or other problems needing instructor (or another) solution. Fortunately, such changes or corrections may be made quickly and easily by going to the typewriter terminal and typing the revisions. The fact that such changes can be made relatively easily, means that programs can be kept up-dated and dynamic. Materials found to be inadequate or in need of further development need not be kept in while waiting for the next edition, one of the main problems with programed texts.

The second part of the objective for this evaluative study was to lead students weak in any specific area through a specially designed learning program. Here again, the original design called for stopping after the test program and telling the student whether or not he was to go on to a learning program. Mechanical problems and lack of time to make corrections for this group of students led to a decision to have everyone take both the test and the learning loop. Analysis of the student print-outs and discussions with a sample of forty students was selected as an alternative method of assessing student reactions to the testing and learning loop combination. Subsequent analysis of the print-outs showed that weak students did in fact improve their scores in most cases by as much as 100 per cent. This was not unexpected since the learning programs were written so that students should have been able to answer the questions if they had properly understood the preceding material. We may conclude, therefore, that this objective was met; that students' weaknesses in certain knowledge areas could be profiled using CAI and that the learning programs did assist them in being able to respond with the correct answers.

CONSIDERATIONS FOR THE DEVELOPMENT OF SOCIAL WORK CURRICULA USING CAI

Recent advances in the field of computer and media technology have opened opportunities for the social work educator never before available.

This new technical knowledge comes at a propitious time, since it coincides with significant developments in the behavioral sciences. Research in this area, much of it government funded, is resulting in quantities of data and resultant theoretic conceptions rich in implications for social work curricula. Computer based instruction and computer simulations in decision making provide ideal pedagogical vehicles for implementing new dynamic curricula. The flexibility of CAI is such that other media (films, audio tapes, slides) may be integrated into the programs resulting in a highly effective approach to the student. Results of a program in Physics, e.g., being conducted at Florida State University using this type of integrated media is producing some significant data. In tests given to experimental and control groups, the CAI-participating students performed approximately ten per cent better on all four, one-hour exams.[3] How well students perform after CAI is still under investigation. The CAI Center presently has eight curriculum projects in various stages of development; analysis and evaluation of these projects is designed into the research. At FSU the question whether social work curricula may feasibly be designed for CAI is still being tested and will await more sophisticated research being contemplated in the months ahead.

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[3]Duncan N. Hansen and Walter Dick, Semiannual Progress Report January 1, 1967 through June 30, 1967, Tallahassee, Florida Computer-Assisted Instruction Center, Florida State University, p.41.

In order to properly design the programs or software that constitute the teaching materials of CAI, social work educators may begin now to think of the following: (1) What subject matter is basic to the field; (2) What skills are basic to problem-solving, diagnosis, interviewing, therapy; and what attitudes, values, understandings, emotional sets are basic to the profession. After establishing these components, the next process would naturally involve testing for validity.

The necessity to move forward rapidly in the development of CAI in social work education is related to manpower needs, insufficient supply of teachers, length of time needed in the M.S.W. program. Educators are saying that "programed learning is here to stay,"[4] and that educators would do well to accept that fact and write the kind of instructional materials required.[5] Social work educators may be presumed to be included in this summons to action. P. Kenneth Komoski, president of the Center for Programed Instruction, New York City, reminds us that,"...with programed instruction we have a tool which makes possible a rigorous, objective analysis of what happens when we instruct.", and better yet, it helps us identify the obsolete by showing us objective evidence of something better.[6]

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[4]Lawrence M. Stolurow, "Lets be Informed on Programed Instruction," Phi Delta Kappan, March 1963, p. 257.

[5]*Ibid*.

[6]P. Kenneth Komoski, "Programed Instruction - A Prologue to What?" Phi Delta Kappan, March 1963, p. 292

Komoski relates that when he first started in programed instruction and teaching machines, he queried psychologists who were pioneering in the field: "What are the things that can and cannot be programed for a teaching machine?" "It wasn't long before I learned the stock reply of my psychologist friends: "This is a question that can only be answered experimentally; experimentation and time will tell what can and cannot be programed."[7]

But, there is no denying the fact that anything social work educators do at this point will be very much in the nature of pioneering and they will frequently find themselves in dark forests in which dwell the ubiquitous, "I told you so's!"

PROBLEMS

What are the problems? A few of the major ones include: (1) Identification of the significant concepts which must be taught in the theory and practice courses; (2) Submitting the concepts to the scrutiny of colleagues; (3) Writing curricula suitable for programed learning; (4) Adapting the curricula to computer based instruction and allowing for the use of additional media along with the computer; (5) Selecting learning situations which may be simulated and which can be taught via CAI and related media instruction; (6) Adequate research funds--because the development of new curricula will take a lot of time and cost a great deal of money. Not mentioned before is the need for access to a CAI system.

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[7]Ibid.

At the time of this writing, only eight universities have operating CAI programs, but this should not deter anyone from moving forward. Hardware is not the problem; but the programs themselves, the software, are.

AN INVESTIGATION OF COMPUTER-BASED SCIENCE TESTING

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Introduction. The sequential model of testing as opposed to the conventional cumulative test model directs the examinee to subsequent items on the basis of his prior responses. In operational terms, as the examinee completes a test item, the outcome is immediately evaluated, and this information becomes part of the test history file upon which a decision rule is applied in order to determine the next test event. Obviously, no examinee attempts all the items in the sequential test, but rather responds to any of a variety of combinations of items. This paper will concern itself with the empirical findings of sequential testing as it affects test reliability, validity, scoring procedures, and the pragmatics of test administration.

The availability of an interactive computer system and its capability for response analysis, record-keeping, and contingent branching is an integral component within our approach to sequential testing. While interactive computer systems resolve the logistic problems of administration, they raise new considerations relating to examinee's adaptation and attitude towards the electronic equipment, the type of testing, etc. Moreover, new test construction techniques and preparation factors like computer coding, operational costs, etc., have to be considered if a reasonable documentation of the feasibility and cost effectiveness of computer-based testing is to occur.

We turn now to a more specific background review of the psychometric questions we investigated. In principle, the capability of computer-based testing to branch examinees to easier or more difficult test items, depending upon the preceding performance, should increase measurement discrimination. Moreover, one would expect conventional measures of reliability to improve for at least the following two reasons. First, score variances should be greater due to the spread created by branching procedures. Patterson (1962) found this outcome of increasing variance to be especially beneficial at higher and lower ends of the score distribution in a computer simulation study of sequential testing. As Waters (1964) demonstrated in a similar simulation study, sequential testing leads to a more rectangular score distribution and potentially a greater dispersion of scores. We planned, therefore, to attempt to empirically replicate this finding.

As a second contribution to improved reliability, the effect of sequential branching should more optimally match examinees' performance levels with test item difficulty levels and, consequently, reduce the amount of guessing behavior. Shuford and Massengill (1966) demonstrated theoretically the attenuating effect of guessing on test reliability. Thus, we planned to provide for an empirical comparison of reliability of a conventional cumulative test and a computer-based sequential test in a natural academic setting.

Since all of the items in a sequential test are not attempted by all examinees, conventional techniques for estimating reliability are nonapplicable. To circumvent this obstacle, we created and investigated scoring schemes that utilized the hierarchical item difficulty structure of the sequential test and allowed for an assignment of all item scores by all examinees. This procedure will be more thoroughly covered in our subsequent section on scoring methodology for sequential tests. The important question is whether we can create a reasonable and valid procedure for estimating reliability so that practitioners can derive reliability coefficients for sequential tests, especially those under construction.

The implications of sequential testing for test validity can best be viewed within the context of the "attenuation paradox." As Gulliksen (1945) first pointed out, validity and reliability are not monotonically related, and undue increases in item precision will lower the validity of the test. Or, as Tucker (1946) demonstrated, medium-ranged item intercorrelations yield the better relationship to an ability criterion under conventional scoring procedures. Scoring procedures (Gulliksen, 1945), the score distribution (Humphreys, 1956), a curvilinear relationship of test scores to ability criterion scores (Brogden, 1946), and the effects of strata of abilities in the criterion distribution (Lord, 1955) have been offered as explanations for the "attenuation paradox." For sequential testing, the problem of cumulative correct/incorrect scoring is easily avoided. Using various scoring schemes, we hoped to demonstrate that a sequentially organized achievement test will have a higher relationship to a criterion ability measure than a conventional achievement test. This predication is based on more optimal branching of examinee's performance status to levels of item difficulty in sequential testing, plus the use of scoring procedures that assign differential amounts to item difficulty levels. We also investigated a number of ability measures in order to assess empirically the full range of possible relationships.

In regards to computer-based sequential testing, the validity of the measure may be improved by the utilization of multiple dependent measures, such as confidence rating or response latencies, in addition to correct/incorrect responding. In the second experiment to be reported, we investigated the role of confidence ratings as an additional performance indicator.

Since computer-based testing is still novel in a university setting, obvious situational and procedural variables are worthy of investigation. Prior experience interacting with the computer-assisted instructional system employed in these studies may provide a facilitating adaptive effect. We, therefore, selected for the first experiment half of the examinees who had at least one hour or more of experience interacting with review and problem materials appropriate to an introductory collegiate physics course. Moreover, we were interested in determining whether these CAI-experienced examinees would have shorter work times as contrasted with the naive examinees. In addition, we wished to compare the work time in the computer-testing situation with conventional testing work times. Krathwohl (1959) reported that noncomputer-based sequential testing is approximately 2 to 2.5 times as long as conventional cumulative testing. Undoubtedly, this increased test time may be attributed to the complex directions and procedures of finding coded sequences in a bulky test booklet. As a related variable, we were interested in the attitudes of the examinees towards computer-based testing.

<u>Scoring Procedures</u>. We turn now to a discussion of the scoring schemes that we investigated in order to both understand their empirical implications as well as their impact on the psychometric characteristics of the sequential test. We utilized the content of a within-term examination in physics that covered the topics of mass, force, momentum, energy, and work. For each of these concepts, we constructed an item tree network that allowed an examinee to be routed to difficult or easy items, depending upon his performance. Test items according to difficulty were assigned to each of numbered node positions. The initial item had an expected difficulty level of .50, and each subsequent level differed by approximately .10 of item difficulty. For scoring purposes, each terminal node item had two hypothetical nodes added in order to indicate success or failure on the last item in the sequence. (See items five through fifteen in Figure 1.) The performance of each examinee on a concept resulted, then, in an ordered array of node numbers. The 16 possible node number arrays will be referred to as pathways.

Insert Figure 1 about here

In most sequential test studies, the final node position is assigned a rank that becomes the examinee's score. In terms of Figure 1, there are five final rank scores. We refer to these as <u>Final Node Scores</u>.

As there are various pathways that lead to rank final node positions two, three, and four, different examinees can attempt differing item difficulties and still receive the same final score. We therefore assigned 16 rank scores to the possible pathways, giving the better rank positions according to difficulty levels of the attempted items. We refer to these scores as <u>Pathway Indices</u>.

For purposes of calculating a reliability coefficient, it would be desirable to have a score for each of the node positions and associated test item. Given that the test items are hierarchically arranged by difficulty levels and representative samples for that difficulty strata, we investigated the following scheme that makes an assumption about the examinee's performance if he had attempted all items. If an examinee was successful on an item, we gave a score of two for that item and for all other items below in the vertical array at that node point in the tree structure. We also assigned a score of one to the item directly above on the basis that there was a probability of .50 of successfully completing it if it had been attempted. If the item was failed, the item score was zero for it and all items above in the tree position array. A score of one was assigned to the next items below, and a score of two to all other vertical items below. In this scoring procedure, the hypothetical terminal nodes were not considered. To illustrate, if an examinee failed node item eight, a score of zero was assigned to node items four and eight, a score of one to node item eleven, and a score of two to node item thirteen. If the examinee had passed node item eight, then he would be given a score of two on node items eight, eleven, and thirteen, and a score of one on item four. This scoring procedure makes a strong assumption about the monotonic relationships of item difficulty and performance. We refer to this scheme as the <u>All-Item Score</u>.

For purposes of comparison, we also considered a conventional cumulative score for attempted items. This is referred to as the <u>Sum Score</u>. Thus, we considered four scoring schemes for each of the five subtests. A total test score for each scheme was a sum of the five subtests.

<u>Materials</u>. The computer-based sequential test was designed to be a parallel measure of achievement found in a one-hour classroom examination that covered the topics of mass, force, momentum, energy, and work. Items for the sequential test were selected from a large pool of items collected from exams given by the same professor in previous years. The item difficulty statistics were somewhat ambiguous in that they represented many different student populations and were found in both within-term and final examinations. To better insure the item difficulty levels, a panel composed of the professor, two physicists, and two physics curriculum writers rated all the potential items into seven levels of difficulty. For the selected items, all of the panel agreed as to the level of difficulty. For the topics of mass, momentum, and work, our inability to complete the seven levels of difficulty led us to restrict the size of the item tree to three arrays or six items representing five levels of difficulty. We were able to achieve the seven levels of difficulty for the topics of force and energy.

Since an examinee attempted only a subset of items due to the pass/fail decision rule that directed the student to the next higher or lower node item, the total test consisted of 17 items from a total of 38 available items. All of the test items as well as the 20-item classroom test were in a multiple-choice format. Figure 2 illustrates a typical item plus the confidence rating format utilized in Experiment Two. The directions for the confidence rating were part of the general introduction to the testing situation and required the examinee to indicate his confidence over a nine-point scale.

Insert Figure 2 about here

General Procedures. Since some students were unfamiliar with our CAI system, we briefly explained to all participants the procedures for activating the computer program, how to enter an answer, how to make corrections, and how to sign off or terminate. This introduction took less than five minutes due to the simplicity of the procedures; no additional help was required. Scratch paper was provided for calculations, and answers typically consisted of the numbers "1" through "5" plus an entering response. The CAI system response typically was two seconds before the next item was presented.

The test was controlled by an IBM 1440 CAI system, and the actual presentation was given via IBM 1050 terminals. There are seven of these typewriter terminals at the FSU-CAI Center; each terminal is located in a separate, isolated room. Each student proceeded individually, and total work times were collected. The computer-based test was administered approximately one week after the regular class examination. It required three days to schedule and process all of the participants.

Experiment I. The first experiment, in essence, was an initial study in the empirical feasibility of computer-based testing. The questions relating to reliability, validity, and procedural factors were of primary interest. Fifty-six freshmen (25 men and 31 women) were randomly selected from approximately 480 students enrolled in the Fundamentals of Physics course in the winter term of 1967 at Florida State University. Half of the selected participants had prior experience with the computer terminal at the CAI Center. This prior experience consisted of review physics problems for the preceding class examination. Each had taken a 20-item class examination the previous week.

Results. In order to evaluate the appropriateness of the item difficulty assignment, the fact that all examinees attempted the first item on each of the five subtests offers evidence as to the accuracy of the test construct procedures. As indicated in Table 1, the empirical difficulty level approximates the desired level of .50.

Insert Table 1 about here

In regards to the interrelationship among the various scoring methods, it can be shown that there is a monotonic constraint as to the overall score for the four methods; that is, a simple sum of the correct items will be directly related to the final node position. As indicated in Table 2, the intercorrelations of total scores among these various scoring methods are substantially high. It is worth noting in Table 2 that the hierarchical All-Item Scoring scheme has the lowest relationship to the other procedures. Still though, the relationships are close enough so as to encourage the use of the All-Item Scoring procedure for the calculation of reliability estimates. Given these high relationships, and for the purposes of simplicity presentation, we shall use the Final Node score and the hierarchical All-Item score for the determination of other psychometric characteristics of the sequential test.

Insert Table 2 about here

Since one of the objectives of the sequential test is to achieve a uniform score distribution, we tested the Final Node scores and the hierarchical All-Item scores using the Kolmogorov-Smirnov cumulative distribution goodness-of-fit test. In both cases, there was no significant difference from the uniform distribution ($P > .30$) We again interpret this outcome as evidence that the empirical outcome for the All-Item scoring procedures is maximizing the spread in the score distribution.

Reliability. As has been noted above, only the hierarchical All-Item scoring procedure allows for the use of conventional reliability estimation techniques. As can be noted in Table 3, an analysis of variance technique (Rabinowitz & Eikeland, 1964) approach to estimating a Kuder-Richardson 20 for stratified tests indicated that the overall reliability for the sequential physics test yielded a coefficient of .885. Perhaps even more encouraging was the high subscale reliability coefficients. The higher estimated coefficients for force and energy can be attributed to the fact that these had more items present in the testing sequence.

Insert Table 3 about here

In comparing the sequential test with the conventional test, it was found that the 20-item classroom test yielded an overall K-R 20 coefficient of .515 The subscale clusters tended to range from .141 through .398. In order to provide a fairer comparison due to differential length, one can utilize the Spearman-Brown formula to increase the 20-item conventional classroom test to a similar 38-item pool employed in the sequential test; this yields an estimated reliability of .668. In both cases, the reliability coefficient for the sequential test is significantly greater than that for the 20-item classroom test. Moreover, the reliability for the sequential test compares quite favorably with that found for most standard achievement tests currently available. We also feel that the evidence from the relationship of the hierarchical All-Item scoring procedure to the other scoring procedures offers some sustaining evidence that this approach for estimating reliability for a sequential test is viable and sound. We would contend that a procedure to calculate conventional reliability estimates will be invaluable to investigators who are constantly reworking tests for investigatory reasons.

Validity. The method which was chosen for validating the computer-based sequential testing approach and the accompanying scoring schemes was the correlation of these scores with the score on the conventional class test plus the score on the final classroom examination. These are presented in Table 4.

Insert Table 3 about here

Although all of the resulting correlation coefficients are statistically significant, the overall relationship to the classroom test scores is sufficiently low enough to indicate some difference between these two methodological approaches. Perhaps the major reason for these low correlations may be due to the low reliability of the class test. As reported above, the conventional test had a K-R 20 reliability estimate of only .515. Moreover, the mean score for the 20-item classroom test was 15.5, with a standard deviation of 2.3. This skewed distribution may have reduced the correlation coefficients due to a restriction in range in the scores. It is also worth noting that the relationship between the classroom test and the final grade in the course is substantially lower than that found for the computer-based sequential test; that is, the correlation coefficient of the classroom test with the final grade was .19, while the All-Item sequential score yielded a correlation coefficient of .49 with the final grade. (See Table 5.)

Insert Table 5 about here

Thus, the sequential test was a better predictor of the final achievement of the students.

Perhaps the most persuasive substantiation of the worth of the sequential testing approach is indicated in the more substantial correlation between the hierarchical All-Item scoring outcomes and that of the participants' score on the Florida Twelfth Grade College Examination. The Florida Twelfth Grade College

Examination is a sum of a verbal and mathematical aptitude score. As is indicated in Table 5, the hierarchical All-Item correlation coefficient with this ability measure is .43. The relationship to the conventional class test is substantially lower or is statistically nonsignificant from zero. As indicated in Table 5, the sequential test scoring procedures yielded moderately better relationships to the ability measure than did the final course grade. We feel that this first sequential testing experiment has documented the potential efficacy of this approach to improving the relationship of collegiate achievement to ability selection criteria.

Testing Time and Administrative Factors. An issue of prime importance is the administration and adaptation factors required by computer-based testing. As indicated in the design, there were two groups which varied as to prior experience with computer interactions. In terms of their test performance, there were no significant differences between the group means ($P > .15$). Therefore, the familiarity with the computer terminal and its operation appears to have no discernible effect on the examinees' scores. As noted in the procedures section, the introduction to the computer terminal operation is brief and simple in nature. Computer response time also allows for a smooth flow of questions. Thus, each examinee has opportunity for self-pacing through the test materials.

The time used by the students in this study was carefully recorded under both testing conditions. Utilizing a two-way analysis of variance with prior computer experience and work time as the factors, we found a significant difference in favor of computer-based testing in terms of work time ($P < .05$).

The mean time for the 17 items on the computer system was 25.04 minutes as compared to 30.73 minutes on the 20-item classroom test. These mean times average out to 1.47 minutes per item under computer control in comparison with 1.54 minutes for the classroom test items. Again, there was no significant difference with regards to prior computer-interactive experience nor a significant interactive effect. The correlation between the time required for the two test situations was r = .21. We interpret this low relationship as indicating considerable individual differences in work strategies in these two testing situations. Further investigations should explore the cognitive and/or personality variables that would predict work time in varying testing situations.

It should be noted that the computer-based sequential test was more difficult in nature and, consequently, in principle should have slowed the examinees' work rate. Moreover, each of the questions was typed out at the rate of 13 characters per second. This type-out rate also reduces the amount of time in comparison to a conventionally presented test. As noted in the introduction, the computer-based work times are exceedingly favorable in comparison to the times for conventional sequential testing (at least three to four times longer) as reported by Krathwohl (1959). Thus, the improvements in computer technology have decreased the overall test-taking time for the examinees in sequential testing situations.

We view the outcomes of Experiment One as establishing the feasibility of computer-based sequential testing. Moreover, we find the investigation as to various scoring procedures of value in that we were able to generate a seemingly appropriate scheme by which one can provide for conventional item reliability estimation procedures. . Moreover, both the reliability and validity characteristics of the sequential test were superior to that of the conventional classroom test. Perhaps the most noteworthy result was the better, but moderate, relationship between the sequential test and the ability criterion measure. This finding directly relates to the discussion on the "attenuation paradox" and indicates that sequential testing may provide a viable way of increasing item precision without introducing a ceiling effect on validity relationships.

Experiment II. The second experiment focused on the relationship of examinee's confidence ratings on completed test items to the other variables relating to reliability and validity. More explicitly, we wondered if the prediction of concurrent achievement such as the class test, the final course grade, and the ability criterion measure can be substantially improved if confidence rating scores are combined with the sequential test score. In addition, we gathered attitude reactions on the part of the participants towards the computer testing situation in order to assess any negative reactions. Obviously, we also wished to replicate the findings of the first experiment in that the All-Item scoring procedure led to improved reliability and validity relationships.

Thirty freshmen were randomly selected for this study from approximately 300 students enrolled in the physics course at FSU during the spring term of 1967. All of the subjects were naive in terms of their exposure to computer interaction. Each examinee had taken a newly constructed 20-item class test approximately one week prior to the computer-based sequential test.

In order to effectively gain confidence ratings on test items, introductory directions were presented as portrayed in Figure 3. In addition to the explanation, one sample problem with an opportunity to rating one's confidence was included in the pretest introduction. Thus, each examinee had an opportunity to solve a very simple physics problem and give a confidence rating. This simple introduction to confidence rating was pretested with college students here at FSU and has proven to lengthen the introduction by approximately three minutes.

Insert Figure 3 about here

Results. As in the prior examination, the mean correct proportions on the initial item of the five subtests were bounded between .43 and .57. This lends further evidence that the item difficulty levels of the sequential test were appropriately assigned. The interrelationships between the four scoring methods and the confidence scores are presented in Table 6.

Insert Table 6 about here

The interrelationships among the scoring methods are almost equivalent to those found in Experiment One, in that the high intercorrelations among the scoring procedures are still present. The relationships with the confidence ratings, on the other hand, were considerably lower although comparable to similar results found in learning studies for confidence ratings.

In terms of reliability, the hierarchical All-Item scoring approach yielded a more substantial Kuder-Richardson 20 coefficient of .904; the subscale reliabilities were bounded between .58 and .88. In comparison, the classroom test yielded a K-R 20 reliability of .697. Again, the computer-based sequential test appears to have better reliability characteristics. The K-S goodness-of-fit test for a uniform distribution indicated no significant differences. These results further substantiate the reliability outcomes of Experiment One.

As can be seen in Table 7, the validity relationships tend to replicate those found in Experiment One. The class test has improved as a predictor of the final grade performance. The confidence ratings are moderately related to the validity measures. An analysis of variance approach to multiple regression was performed in order to determine the combined relationship of the sequential test scores plus the confidence rating. Regressing on the parallel class test, the combined measures of the All-Item score plus the confidence score yielded a multiple R of .438. The multiple R improved for the final course grade to .739.

Insert Table 7 about here

An improved prediction of the Florida Twelfth Grade ability measure yielded a multiple R of .618. In all cases, the beta weights of the hierarchical All-Item sequential score plus the confidence score were significant, although the All-Item score had substantially higher beta weights. In terms of this experiment, the availability of a confidence rating score does improve the prediction of both concurrent achievement and ability criterion measures. Obviously, computer-based testing allows for the gaining of these multiple dependent measures with relative ease.

Turning now to the analysis of work times for the class test and computer test, there was no statistical difference. The mean time was just over 30 minutes for total presentation; the item time for the 17 CAI items plus confidence rating was 1.79 seconds, and that for the conventional class was 1.71 seconds. Thus, the time factor was equivalent for both testing situations.

At the termination, the examinees filled out an attitudinal scale adapted from a CAI Attitudinal Scale prepared by Brown and Gilman (1967). Table 8 presents the ten item statements that were rated on a five-point scale that typically ranged from "strongly disagree" through "uncertain" to "strongly agree." In Table 8, the mean value and nearest associated word from the scale are also presented. Balancing for positively and negatively worded statements, the examinees reacted to the computer-based testing situation with favorable ratings. Item 4 is especially interesting in that the vast majority of examinees reported that they never guessed at answers. We interpret this report as indicating sequential testing minimizes guessing since item difficulty is being adjusted to prior performance. These positive attitudinal results are similar to those found for a well-prepared CAI course presentation.

Insert Table 8 about here

Cost Factors. The current and future costs of computer-based testing will vary considerably due to a number of factors as follows: (1) the kind and cost of the computer terminal, (2) the size of the computer system, (3) the use and cost of teletransmission, and (4) the amount of real-time analysis required to utilize multiple dependent measures. Our current hourly cost at FSU for IBM 1440 terminal time is $2.56. This is obviously many orders of magnitude higher than the costs for conventional testing.

Two additional factors may also increase these cost estimates. First, sequential testing requires two to three times the number of test items, depending on the size of the item tree structures. Consequently, sequential testing has a higher cost where new item construction is required. Secondly, the test items must be encoded for the computer system. This typically costs approximately $.50 per item.

There are many possible savings that accrue to computer-based testing. Obviously, the costs of printing, handling, etc., are included in the costs of the terminal charge. The costs of scoring and processing answer sheets at a test center are also included in our charge for terminal time. Thus, many of the hidden logistic costs of conventional testing are minimized within the computer approach. In the future, one can anticipate further cost reductions in computer applications, whereas it is difficult to anticipate any cost savings via conventional approaches. Ultimately, any improved reliability and validity characteristics of computer-based sequential testing will have to be compared in a cost/utility sense against the increased fiscal costs of this technological approach.

Summary. Our empirical study of computer-based sequential testing substantiates for us the feasibility and potential worth of this methodological approach. Our investigation of various scoring schemes indicates the close empirical similarity of the various procedures. Moreover, the technique for assigning values to all items via the hierarchical All-Item scoring procedure appears to resolve the problem of estimating reliability within sequential testing. The replicated evidence on the high relationship among the scoring procedures, the performance on the common initial item in each of the five subtests, and the score distribution analysis support our view that the All-Item scoring procedure can be utilized without undue jeopardy by an investigation in estimating test reliability for tests under development.

More importantly, the relationship between confidence ratings and item scores plus the consequent improvement in multiple R prediction of concurrent achievement or related ability measures represent the strongest empirical evidence, from our viewpoint, as to the potential worth of computer-based sequential testing. Future investigators may wish to explore the use of confidence ratings or other related dependent measures in their techniques for assigning item scores in order to generate better reliability estimates. The improvement in the relationship between computer-based sequential achievement testing and validity has direct implications for college selection procedures. If the relationship between the college selection tests and college academic achievement can be improved via sequential achievement testing, then many obvious cost and human savings can be effected.

The results on work time indicate to us the desirability of utilizing a computer technological approach to sequential testing. While the costs of student testing time can be assigned a variety of values, we would contend that shortening test time allows for a more broadly based approach to academic assessment. While the attitudinal findings are of a very preliminary nature, we do take encouragement in that no negative factors were encountered in our studies.

In terms of the future, there are obvious needs to further explore the size and shape of the item tree structures as these relate to theoretical considerations within test theory. While our approach has been empirical in nature, we could claim that further exploration as to the theoretical nature of sequences of item structures will be required before a broad understanding of this approach can be achieved. Moreover, the obvious information retained in response latencies has not even been explored within these experiments. There are sufficient findings from learning experiments which indicate that response latency may prove to have just as powerful an impact on the predictive relationship to criterion measures as did the confidence ratings.

As a last note for future study, we would suggest that computer-based approaches to testing may allow for an acceptable and feasible way of controlling test anxiety. The conception is to adjust the item difficulty level for each examinee in order to minimize the extreme anxiety reactions found when examinees are working on impossibly difficult test items. We have demonstrated in a learning experiment (O'Neil, Spielberger, and Hansen, 1968) that state anxiety ratings, blood pressure, and error rates are highly related, and that anxiety status can be manipulated according to the difficulty level of the learning materials. The future of computer-based sequential testing, therefore, has many avenues of needed investigation. We trust this paper will provide a new stimulus for further research in the area.

FIGURE 1

CONCEPT ITEM TREE NETWORK, PATHWAY STRUCTURE AND NODE NUMBERING FOR SCORING METHODS

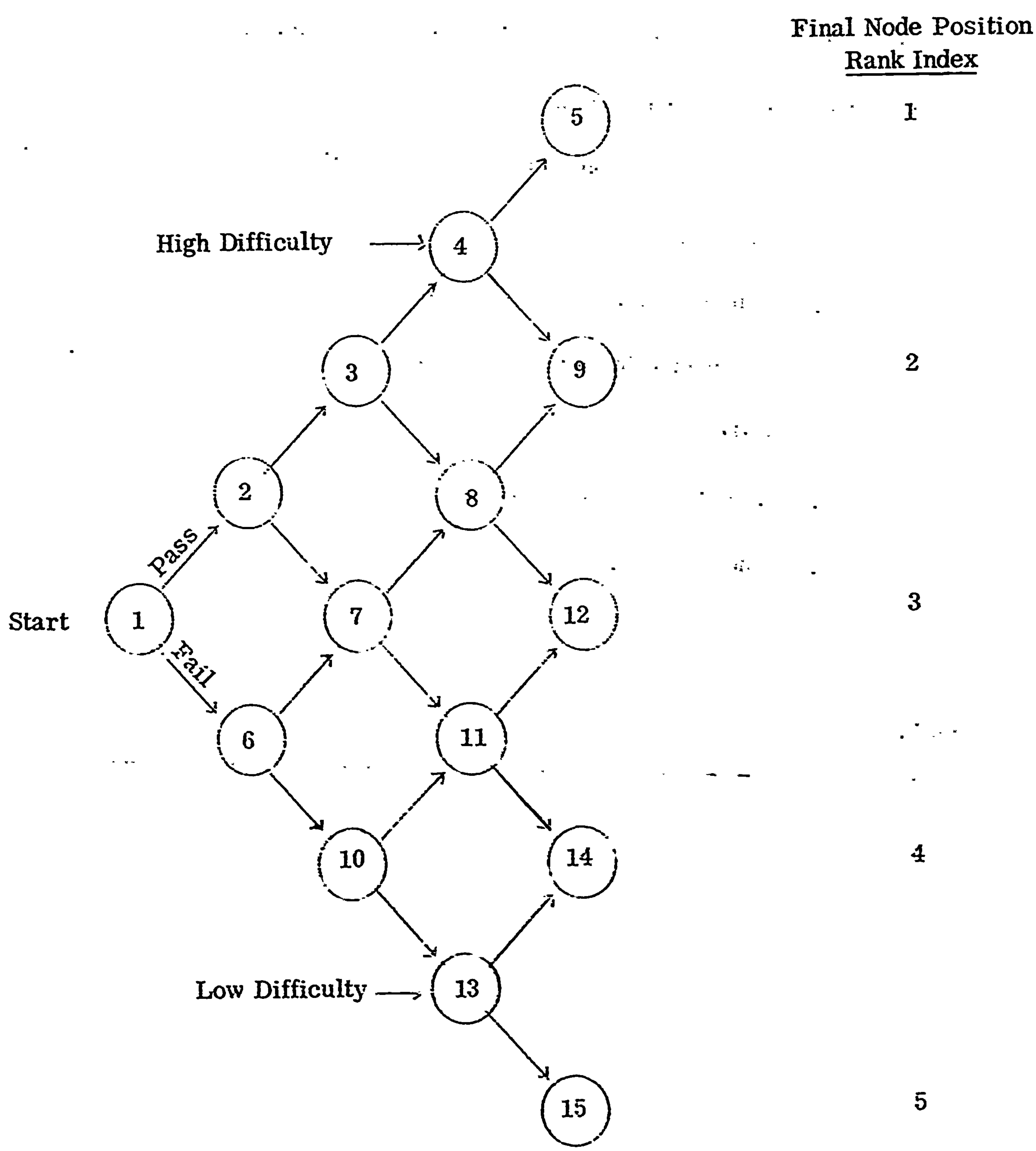

FIGURE 2

TYPICAL TEST ITEM FORMAT

A certain body is observed to be moving with a constant momentum of 100 kilogram meters per second. Ten seconds later the same body with the same mass is observed to be moving with a constant momentum of 200 kilogram meters per second. We can conclude that

1. a net force acted on the body during the ten seconds we weren't observing it.
2. no force acted on the body during the ten seconds.
3. this change in momentum is not associated with an acceleration of the body.
4. the velocity of the body has not changed.
5. none of these.

(Answer) 1

Confidence ________

FIGURE 3

DIRECTION AND FORMAT FOR THE CONFIDENCE RATING

After each question of this test you will be asked to express the confidence you place in the correctness of your answer. This expression of confidence will be based on a scale from 1 (which signifies no confidence) to 9 (which signifies extreme confidence).

The following scale will be helpful to you in rating your confidence:

no confidence 1

moderately unconfident 2

mildly unconfident 3

slightly unconfident 4

uncertain 5

slightly confident 6

mildly confident 7

moderately confident 8

extremely confident 9

Following your response to each question, "confidence ____" will be typed at which time you are to reply with an integer from 1 to 9 in the blank provided. When you need to refer to the scale at any time thereafter use the mimeographed sheet next to the terminal.

FIGURE 3.--Continued.

SAMPLE

Now answer the following sample question and, when indicated, rate your confidence in the correctness of your answer.

Express the following number in scientific notation: 502,785.

1. 502785 x 10**5
2. 5.02785 x 10**5
3. 5.02785 x 10**6
4. .502785 x 10**7
5. 502,785 x 10**2

(Answer) 2

Confidence ______

You have rated your confidence between 6 and 9 which indicates that you have answered the question with some degree of certainty. The correct answer is 2 (5.02785 x 10**5).

TABLE 1

MEAN CORRECT PROPORTIONAL ON THE INITIAL ITEM FOR THE FIVE PHYSICS SEQUENTIAL TREE STRUCTURE

Concepts	Mass	Force	Momentum	Energy	Work
Mean Proportion Correct	.572	.518	.554	.464	.500

TABLE 2

PRODUCT-MOMENT CORRELATIONS AMONG THE

FOUR SCORING PROCEDURES ON THE

SEQUENTIAL PHYSICS TEST

	1	2	3
(1) Final Node			
(2) Pathway Index	.912		
(3) All-Item	-.887*	-.904	
(4) Sum Score	-.936	-.906	.843

*Negative correlations are due to the ranking procedure.

TABLE 3

CONCEPT SUBSCALE

KUDER-RICHARDSON 20 RELIABILITY ESTIMATES

Concepts	Mass	Force	Momentum	Energy	Work	Total
Reliability Coefficient	.681	.847	.718	.829	.736	.885

TABLE 4

PRODUCT-MOMENT CORRELATION BETWEEN THE SEQUENTIAL SCORING PROCEDURES, THE CLASSROOM TEST, AND THE FINAL GRADE

Scoring Methods	Classroom Test	Final Grade
Final Node	-.32	-.41
Pathway Index	-.28	-.43
All-Item	.32	.49
Sum Score	.39	.38

TABLE 5

INTERRELATIONSHIPS OF SEQUENTIAL TEST SCORES AND VALIDITY CRITERION MEASURES

	1	2	3	4
(1) Final Node				
(2) All-Item	-.89			
(3) Class Test	-.32	.32		
(4) Final Grade	-.41	.49	.19	
(5) Ability Measure	-.37	.43	.13	.34

TABLE 6

INTERCORRELATIONS OF THE SEQUENTIAL TEST

SCORING PROCEDURES FOR

EXPERIMENT TWO

	1	2	3	4
(1) Final Node				
(2) Pathway Index	.907			
(3) All-Item	-.893	-.898		
(4) Sum Score	-.923	-.904	.862	
(5) Confidence Score	-.271	-.283	.389	.192

TABLE 7

INTERCORRELATIONS OF SEQUENTIAL TEST SCORES, THE ACHIEVEMENT MEASURES, AND ABILITY MEASURE FOR EXPERIMENT TWO

	1	2	3	4
(1) All-Item				
(2) Confidence	.39			
(3) Class Test	.34	.18		
(4) Final Grade	.56	.43	.31	
(5) Ability	.49	.37	.11	.32

TABLE 8

ATTITUDINAL RESPONSES TOWARDS COMPUTER-BASED

SEQUENTIAL TESTING

		Mean Scale Value	Nearest Associated Word
1.	While taking the computer test, I felt challenged to do my best.	4.1	Agree
2.	I was concerned that I might not understand the material.	3.9	Agree
3.	While taking the computer test, I felt isolated and alone.	2.6	Some of the time
4.	I guessed at the answers to questions.	1.2	Very Seldom
5.	I was more involved in running the machine than in understanding the question.	1.1	Never
6.	I was aware of efforts to suit the material specifically to me.	2.4	Disagree
7.	The computer situation made me feel quite tense.	2.3	Disagree
8.	Questions were asked which I felt were not relevant.	1.0	Never
9.	I could have done better if I hadn't felt pushed.	1.3	Strongly Disagree
10.	I would say computer testing is superior to class testing.	4.2	Agree

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LEARNING OUTCOMES OF A COMPUTER-BASED, MULTIMEDIA INTRODUCTORY PHYSICS COURSE[1]

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This report on FSU's computer-based course in introductory physics, hopefully, will contribute to the growing evidence on the efficacy, limitations, and requirements for a technological approach to instruction. The existence of regular computer-based, accredited courses precedes the FSU Project in at least two instances. The Stanford Project is in the second year of autonomous, computer-based tutorial instruction in reading and mathematics for primary grade children. The University of Illinois' Project has offered a complete, accredited course in library science for graduate students. While many other partial CAI course applications could be cited, the new contributions of the FSU Physics Project can be viewed in terms of four salient features.

First, this introductory physics course for non-science majors offers the opportunity to study a curriculim that has a very rapid increase in conceptual complexity and inter-relatedness. As will be illustrated in the learning results to be presented, the typical learner in the conventional course has a steadily decreasing performance

1 Paper read at American Educational Research Association, Chicago, February, 1968.

curve for this curriculum. Consequently, the CAI physics course has ample opportunity to improve learning outcomes in addition to establishing the feasibility of a technological approach to instruction.

Focusing on a beginning collegiate level course allows one to study the reactions of the fastest growing student populations in the United States. If the costs of CAI courses are to be justified, a rapidly expanding student population group offers an excellent crucible in which to document the benefits of the technological approach. Thus, the study of collegiate freshmen is a new area of exploration for a CAI project.

All CAI courses stress the feature of individualization. The FSU physics course manifests this goal in terms of a number of student-controlled decisions. For example, the FSU students' controlled class scheduling, the opportunity to repeat presentations, and the amount and kind of review materials. Thus, these freshmen had a unique opportunity to control and regulate their learning experiences. This style of individualization is unique, in degree at least, for CAI tutorial courses.

Finally, the FSU physics course utilized a wide variety of multi-media approaches. Rather than restricting the informational presentation to the terminal devices of the 1500 computer system, we chose to employ as many media alternatives as possible. This feature of the physics course offers us an opportunity to analyze the impact of these media types on concurrent concept acquisition behaviors as well as on the final exam. Thus, the physics course may provide information about the relative efficacy of different media approaches.

This report will stress the developmental factors present in creating this computer-based physics course as well as the empirical outcomes of the comparison with the conventional lecture apporach. We report our solutions to the problems of selecting the participating students, the logistics of implementing the course, and the preliminary manpower-cost considerations so that other investigators may assess the full requirements for this kind of educational research.

Research Strategies. The creation and evaluation of a technologically based course of instruction at the collegiate level are fraught with many developmental and methodological problems. During the conception and early phases of this project, a considerable effort was devoted to providing a reasonable developmental design and the appropriate collection of data upon which one could answer questions generic to the "behavioral engineering" or "systems approach" to course development. To be more specific, one must be able to specify in precise terms the need for additional revision based upon fruitful inferences derived from an empirical data base as the curriculum is undergoing the developmental process. Our strategy to resolving this and related formative, evaluational problems can be viewed in a series of systematic procedures moving from the most general to the most specific.

At the most molar level, professional educators are concerned about the overall outcomes of a course. These outcomes are typically judged in terms of performance on mid-term and final examinations. Commonly found in most colleges, and at Florida State University, is the requirement for common examination proceaures for the assignment of course grades. To improve the precision of this comparison, we planned on utilizing three groups for the basis of general course comparisons. The first group, the CAI condition, consisted of those students taking all of the autonomous, multi-media instruction at the CAI Center. The CAI group's only participation in conventional activities was to take the paper-and-pencil, mid-term and final exam. Since the CAI students were self paced in nature, the mid-term and final were offered on a flexible basis when the student reached the appropriate point in the course.

Since we are aware in educational research of the confounding influence of new instructional activities falling under the rubric of the "Hawthorne effect", it is difficult to make a valid cross-group evaluative statement. To overcome this obstacle, a large number of the students attending the Physics 107 class were offered limited CAI interaction covering review, homework, and test topics. We contend that the students in this partial CAI group, which had two to six hours of terminal experience, provide a valid way of assessing the general influence of a new, exciting approach to instruction. Obviously, we planned for a matched group of non-CAI experienced physics students.

As an additional advantage at a more precise level, the partial CAI group provides data on classes of problems parallel in nature to those found within the technologically based autonomous course. Our strategy was to establish a baseline by which we could judge whether various curricular changes were really providing for improvement. The review and problem sessions offered to physics students prior to three within-term and final examinations provided a natural setting in which to collect data in order to judge performance on the concepts covered in the course. As will be explained in the phase development of the project, the collection of this data was replicated over three terms so that we feel we have stable estimates of concept difficulty for undergraduate students at Florida State University. Moreover, we feel that comparing CAI students' performance to baseline data on the physics concepts provides a more precise evaluation of the impact and efficacy of the technologically presented concepts. This comparison helps estimate the need for and degree of required revision.

At the response analysis level of evaluation, the CAI approach to course development provides complete records of responses and latencies as collected in the normal course on instruction. We have devoted a great deal of effort to the development of a data management system by which these responses can be appropriately sorted into meaningful groups for inference-making about the substance of course revisions. Our curriculum writers are finding this evidence to be exceedingly useful in the rewriting of specific presentations in order to accomplish the behavioral objectives set for the course concepts. The judgment about the attainment of behavioral objectives is a difficult one at best and, we contend, best judged in terms of concurrent learning performance as opposed to the sample of behavior on the final examination.

At the most detailed level of research, we are starting to build descriptive models that would characterize the learning activities of the students. The aim of these models is to provide, first, a detailed description of the students' learning activities over the topics found in the course. Hopefully, individual parameters can be estimated within these quantitative models in order to provide empirically based decisions concerning the need for additional remedial or enrichment instruction for the student. It is within these terms that we are hoping to provide a major step forward in terms of individualizing instruction within this physics course.

Developmental Plans. To implement the project strategies and to insure a meeting of our time table for field testing, we developed a phased set of plans. As general characteristics of these plans were two organizational features, namely, the requirement for role differentiation of faculty and project staff and the assignment of tasks to appropriate developmental stages in order to provide for sufficient review that allows for appropriate revisions where required. In considering a feasible, and perhaps optimal, way to develop a technologically based course within the structure of an ongoing University program, it was decided to develop first those parts of the course which could be field tested and evaluated as to their validity and contribution to the course objectives. Given this guiding criteria, the following phases of development took place.

Phase I consisted of the development of a detailed topic outline for the course of instruction. The involved physics professors gave innumerable hours in describing the nature of their introductory course for non-science majors and the techniques by which they presented concepts such as demonstrations, films, etc. This led to a tentative course content outline of a reasonable degree of specificity sufficient so that appropriate review and problem material could be written for each of the topics. These review sections were offered on the CAI system during the fall term of 1966. The material represented a parsimonious statement of the essential concepts found within the topic areas as well as an opportunity to work on problems and multiple-choice test items parallel in content and form to those to be found on the examination. In most cases, the students were required to identify important definitions and relational statements, solve problems, and apply their formed conceptions to test items. Thus, the material could be characterized as an alalogous representation of homework assignments and test content given under CAI presentation. This activity has grown to be exceedingly popular at FSU. We now process nearly 300 students a term with this material. This phase was completed by Christmas of 1966.

Phase II consisted of the detailed response analysis and revision of these review materials. This revision provided us with some indication of how close we were coming to providing problem material which effectively changed the students' behavior in terms of subsequent presentations within the program as well as performance on concurrent class examinations. In addition, we video recorded all of the lecture presentations offered in the conventional classes. These were analyzed for content and for level of specificity. Then, a tentative statement of course behavioral objectives by concepts was generated. The first analysis of the assignment of media to concept presentation was made at this stage. As an additional activity for this phase, all of the film and demonstration materials for the conventional course were programmed from a problem-review point of view. These were included in our review sessions offered to students from the conventional class in the winter and spring term. This phase lasted approximately four months.

In Phase III, a final version of the course behavioral objectives was determined. Figure 1 presents a typical example of the sheets utilized by the project staff. These underwent many revisions and a more specific level was developed for the detailed presentation of material. The results from the video content analysis were then utilized in the final assignment of media presentations. The primary activity of the third phase consisted of the construction of the total CAI course. It is important for you to understand that the course is multi-media in nature and only uses CAI interaction where deemed appropriate after sufficient analysis of the content and behavioral objectives.

Insert Figure 1 about here

Thus, the course consisted of series of text material, film loops, audio presentations, conventional film presentations, and extensive CAI interation. Figure 2 presents a course flow diagram for the topic of light and optics presented in Figure 1. As you can see, we attempted to build lesson structures that would take approximately one hour in duration. The course was completed in early September of 1967 for student presentation.

Insert Figure 2 about here

Phase IV, being the first full-trial test, was completed in December of 1967. We are presently in Phase V which is an analysis of the field test outcomes for the purpose of revising and extending the materials in order to better accomplish our overall goal of individualizing and maximizing the learning of freshman students in an introductory physics course. The revised course will be field tested again in the spring term of this academic year.

Accreditation and Student Selection Procedures. The granting of accreditation to a totally new instructional approach is fraught with many obstacles. Foremost, the university administrator wishes assurance that the "new course" will be equivalent to or better than the existing course. Prior to the first field test, one must appeal to a host of tangential arguments knowing that empirical outcomes might contradict these claims. At FSU, the evidence from the developmental physics CAI review activities indicated a gain of ten to twenty percent in conventional examination performance. This evidence was most persuasive. Secondly, the conventional course instructor, Professor Steve Edwards, has been an active member of the project staff. The positive support and recommendation of Dr. Edwards was undoubtedly the critical factor in gaining acceptance for the first field trial. Even though, the following restrictions became part of our operating policy:

1. The course instructor will retain final editing control of all the CAI physics materials.
2. If, in the judgment of the course instructor, this study is proving to be disadvant geous to the students, he will terminate the experiment at that point.

3. A qualified physics proctor will be available during all instructional sessions.

The CAI students consulted these physics proctors on four occasions during the course. Thus, the need for off-line physics proctors to help solve conceptual problems seems unwarranted. Undoubtedly, the extensive writing and editorial help of Professor Edwards plus the content analysis of the video recording of the conventional course insured that the conceptual coverage was sufficient and styled in an appropriate, meaningful way.

As a final factor in acceptance, the course grades for the CAI course were to be derived from their performance on the conventional course examinations. Since we wish to compare final performance among the three groups, this was a desired condition for the field study. Presently, we are analyzing within course performance in order to find more reliable indices that might replace the exam requirement.

In regard to student acceptance, the administration requested that all selected students voluntarily elect to participate. Since the majority of freshmen at FSU preregister in the summer for the fall term, we selected a pool of 100 students enrolled in Physics 107 and not participating in other freshman research projects such as the Group Cluster Living Project. These students were contacted by mail; and 67% responded favorably, 6% unfavorably, and 27% failed to respond. Thirty of the favorable respondents were randomly selected and notified. Due to course changes and a misunderstanding concerning the one-credit physics laboratory course, seven of the students dropped from the sample. Since classes had met for two sessions, we decided not to replace these seven dropouts, although there were numerous volunteers available. We have no reason to believe that our sample of 23 students is biased or nonrepresentative of the students enrolled in Physics 107. The comparison groups were selected by matching sex and aptitude entrance scores on the Florida Twelfth Grade Examination for each participant and randomly sampling from the pool of available conventional course students.

Course Progress. After a brief introductory and explanatory session on the first class day of the fall term, each self-scheduled his progress through the course. The mid-term exam was given after Lesson 13 and the CAI review on the 1440 CAI-typewriter system. The review session was identical to that offered to the partial CAI group. Since there were two review sessions and two examinations, the course consisted of 33 sessions. Figure 3 presents the cumulative lesson progress curves for the fastest and slowest student.

Insert Figure 3 about here

These curves are typical in that each student tended to cluster his instruction within certain weeks. Table 1 illustrates this clustering phenomenon in that 62% of the lessons were taken in multiple-lesson sessions. There were marked drops in attendance during the mid-term exam period and during certain big, extracurricular events like key football games. The students acknowledged, during their interviews, that they utilized their control of the physics instructional schedule to optimize their participation in other collegiate activities and academic requirements. The student- considered this scheduling flexibility to be one of the key benefits of the CAI course.

Insert Table 1 about here

The mean data of completion was 10.9 weeks in the eleven-week term. When students are allowed to self-schedule, the course completion outcome tends to contradict the common claim that CAI courses will dramatically reduce the length of academic terms. On the other hand, the mean time to complete the 29 lessons was 23.8 hours of instruction. This represents a 17% savings in instructional time. Considering the fixed durations of the films and audio presentations plus the opportunity for repetition of difficult material, this time savings indicates a significant savings in instructional time. It is worth noting that only 3% of the informational presentations were voluntarily repeated while approximately 45% of the CAI interactive responses were repetitive attempts to seek a correct answer. Thus, the prediction of an instructional time savings for CAI was substantiated in this first field evaluation.

Course Procedures. In reviewing our operational procedures, we noted that 95% of the students' questions related to the location and operation of the non-computer, audio-visual equipment. Without a doubt, the 16mm sound films proved to be the biggest scheduling and operational problem area. While equipment failures were minimized by having extra equipment, the effectiveness of operation could only be maintained by having knowledgeable technicians available to set up the films. Moreover, the number of film failures indicates to us that perhaps video tapes may be a more effective approach to solving equipment reliability problems.

In regard to 8mm concept films, we discovered that our introductory and explanatory materials were ambiguous at times. Student comments and learning performance were both lower and more variable for films in general. We are presently investigating techniques to focus attendance in concept film viewing and increasing the amount of interactive questioning interspersed with the viewing.

While the operations of the course required constant attention and service, they were successful in that no student sessions had to be cancelled. Improvements in computer terminal equipment undoubtedly will further resolve these logistic problems.

Performance Results. Turning now to the learning outcomes, the final grade assignments for the three groups indicate a marked superiority for the autonomous CAI students as illustrated in Table 2. Using the sum of the mid-term and final exam scores, a correlated "t" test indicated that the autonomous CAI group was statistically superior while the difference between the partial CAI and conventional students was not significant. The high proportion of "A" grades in the autonomous CAI group represents one of the few instances where the upper half of a score distribution shifted under CAI treatment. It is far more frequent for the lower half of the grade distribution to be truncated due to a CAI treatment. As other analyses will support, we attribute this superior examination performance to the impact of the CAI conceptual interaction sections found within each of the lessons.

Insert Table 2 about here

The comparison of performance on different categories of lesson materials, with the prior baseline data collected during the preparation of the course, provides some insight into the impact of the autonomous CAI lesson material. As indicated in Table 3, we categorized the CAI lesson material into three types of instruction: (1) assessment of textbook reading, (2) assessment of film presentations, and (3) conceptual assessment via problem presentations. For simplification purposes, we grouped the lessons into the five main concept domains of scientific measurement, optics and light, force and energy, electricity, and modern atomic physics. In the last column, we included the baseline physics problem results collected during the developmental phases of the project. As the baseline results indicate, the conventional course performance is marked by a gradual decrease in achievement while the conceptual complexity is judged to be increasing. The performance on the film presentations also indicates a gradual decrement in mastery. On the other hand, the performance on the textbook assessment and the conceptual problem exercises remains markedly constant. We interpret these stable performance levels as indicating a clearer reflection of the performance that resulted in the superior examination scores by the autonomous CAI group.

Insert Table 3 about here

Using multiple regression techniques, we regressed the category lesson scores for the first half of the course onto the mid-term examination score and scores from the second half of the course onto the final examination score. These results are presented in Table 4. The CAI conceptual problem scores yield significantly higher multiple correlations with the examination scores. We interpret these higher associated relationships plus the stable performance levels for the CAI conceptual problems as indicative of the positive impact of the computer interactions on the examination performance. These performance results demonstrate for us that a CAI approach can eventuate in superior conceptual mastery in physics.

Insert Table 4 about here

Before this conclusion appears to be too sweeping, we hasten to report that performance on some of the CAI lessons, as for example the topic of electrical inducation, was far from satisfactory (the mean correct response proportion was close to .40). The performance on the film materials indicates to us a need for extensive revisions in the course. But, if viewed as a first field trial, the learning performance results do support the conception that a computer-based multi-media course that attempts to individualize instruction can eventuate in superior concept mastery.

Attitudinal Results. The attitudinal responses of the students to the Brown Scale on Attitudes Toward Computer-Assisted Instruction indicated a moderately positive reaction to the course.

Without reviewing specific items, the students indicated an awareness of the constrainted dialogue of the CAI materials, tended to guess at times, plus a desire for even more individualization. All of the participants considered the CAI course to be preferable to their corresponding conventional courses.

The personal interviews did reveal two especially important reactions. First, all of the participants indicated a greater sense of concept mastery in comparison to their peers. For example, the participants claimed to be better explainers of homework problems in comparison with dorm-mates who attended the conventional course. The second reaction relates to the man-machine interface issue. All of the participants indicated a preference for the automated typewriter interaction in comparison with the CRT-light pen interaction. While many factors may underlie this unanimous reaction (the flexibility and meaningfulness of the typewriter-presented review material, the opportunity to obtain a personal problem-respons copy, etc.), this finding should be investigated in light of higher costs associated with CRT terminal equipment.

<u>Manpower--Cost Factors.</u> Cost effectiveness analysis in educational technology is fraught with categorization and estimation problems. Foremost for CAI projects, one must clearly differentiate, if possible, between course developmental costs and the operational costs of instruction. Table 5 presents a simplistic breakdown of our cost for the college physics project. Most category items are self-explanatory. The most noticeable discrepancy is the modest cost for actual course operation and the high costs for computer

systems programs. To date, most CAI project reports have omitted the reporting of the high costs involved in implementing a manufacturer's computer system to the status of acceptable operations. While most of the incurred costs for the FSU project may appear substantial in nature, the CAI systems cost represents a one-time investment required to organize and manipulate the learning data so that project goals, especially those of course revision, can be accomplished.

Insert Table 5 about here

Once the developmental costs are amortized, the operation of a CAI autonomous course starts to compare favorably with that of conventional courses.

The question of cost effectiveness requires our assessment of the worth of the improved learning outcomes reported above. While we are attempting to scale these utilizations, I leave you with the problem of assigning value quantities to the unanticipated high proportion of superior grades. Quality education has amorphous characteristics that pose serious obstacles to definitive cost analyses.

<u>Summary</u>. In considering the empirical outcomes from this first field test, we are most encouraged by the substantial, multiple-correlation relationship between the CAI conceptual exercise material and the examination scores that lead to the grade outcomes. We are presently investigating a class of linear models that, hopefully,

will provide us and each student with realistic probability statements about course mastery. If the values become too low, we undoubtedly will prescribe additional practice on a concept. Otherwise, we plan to allow the student to self-define his level of course proficiency. We suspect that the element of student self-commitment may represent a more viable pathway to optimizing the terminal outcomes for an individualized course of instruction.

FIGURE 1

LESSON OUTLINE OF THE INTRODUCTION TO

LIGHT AND OPTICS

Objective:

Introduction to light and optical phenomena.

Concepts Previously Needed and Acquired:

Vectors and vector algebra--a vector is a quantity having both magnitude and direction. Familiarity with vector addition.

Concepts To Be Acquired:

Light travels in straight lines.

Four ways in which light may be bent:

1. reflection--light reflected from a plane surface will have equal angles of incidence and reflection;
2. refraction--light traveling through two transmitting media will experience a change in the path according to Snell's Law $\sin i/\sin r = n_r/n_i$;
3. scattering--reflecting or refracting light so as to diffuse it in many directions;
4. diffraction--modification that light undergoes when passing the edge of an opaque body.

Properties of light and optical phenomena:

1. images--visual counterpart of an object formed by a mirror or lens;
2. real images--light rays appear to converge at the image; image may be detected on an opaque surface;
3. virtual image--no light rays actually pass through or originate at the image;
4. inverted and perverted images--
   - perverted--right and left sides of image interchanged;
   - inverted--top and bottom of image are interchanged.

Ability To Answer the Following Questions:

What is the relationship between the angle of incidence and the angle of reflection for light reflected from a plane surface? (They are equal.)

What are the characteristics of the two basic types of images? (real and virtual)

What are the describing characteristics of inverted and perverted images?

Describe four ways in which light can be "bent".

FIGURE 2

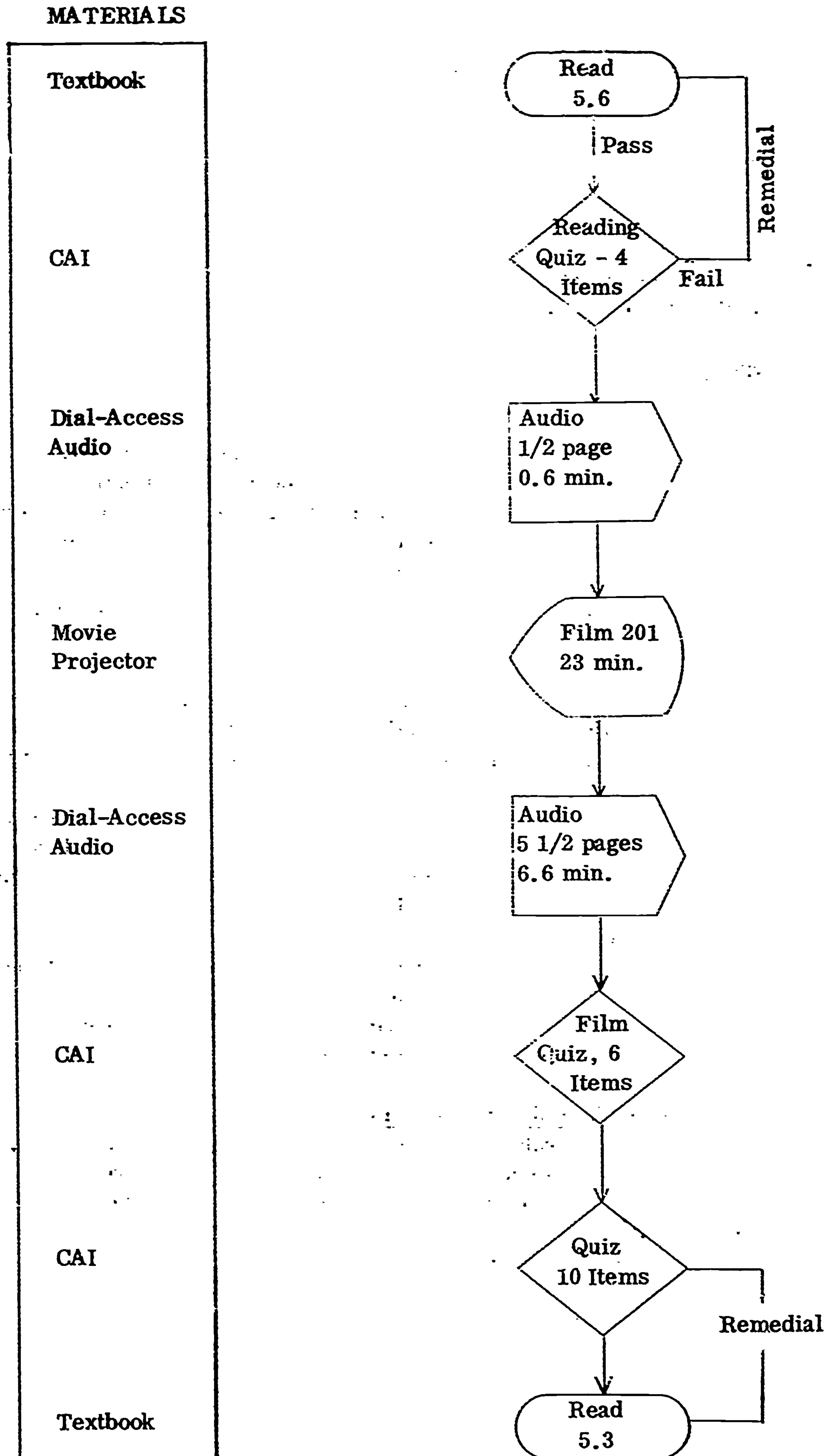
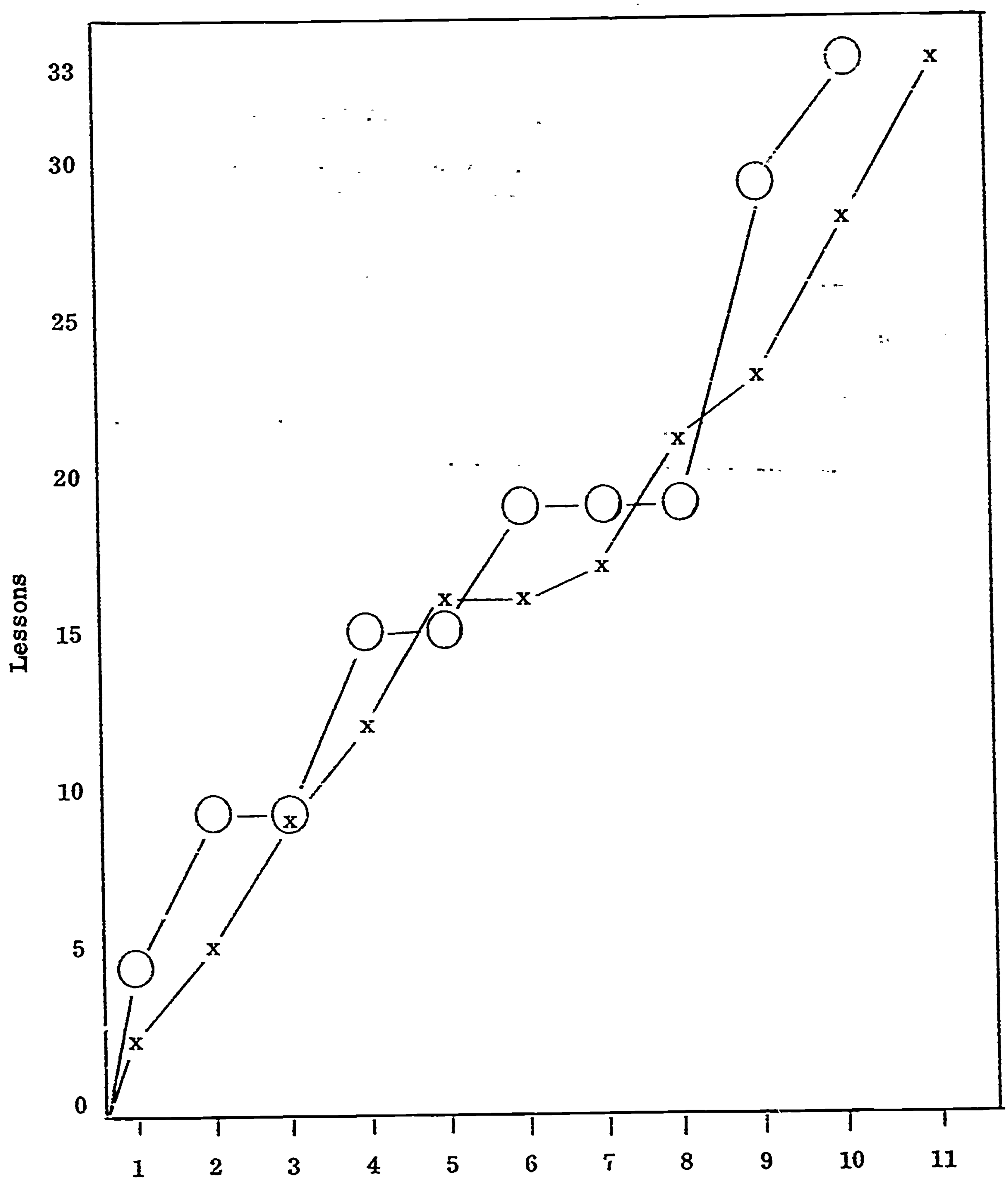

MATERIALS
Textbook
CAI
Dial-Access Audio
Movie Projector
Dial-Access Audio
CAI
CAI
Textbook
Read 5.6
Pass
Remedial
Reading Quiz - 4 Items
Fail
Audio 1/2 page 0.6 min.
Film 201 23 min.
Audio 5 1/2 pages 6.6 min.
Film Quiz, 6 Items
Quiz 10 Items
Remedial
Read 5.3

FIGURE 3

CUMULATIVE PROGRESS CURVES OF LESSON COMPLETION DURING ELEVEN WEEKS OF THE COURSE



◯ -- Fastest Student
x -- Slowest Student

TABLE 1

DISTRIBUTION OF COMPLETED LESSONS BY

ATTENDANCE SESSION

	Number of Completed Lessons Per Session						
	1	2	3	4	5	6	7
Frequency	251	114	40	10	3	1	1
Percentage of Lessons	.38	.34	.18	.06	.02	.01	.01

TABLE 2

FREQUENCY DISTRIBUTION OF GRADES FOR THE THREE INSTRUCTIONAL GROUPS

Conditions	Grades A	B	C	D	Mean Grade
CAI Total	11	6	6	0	3.22
Partial CAI	6	7	10	0	2.83
Conventional	4	5	13	1	2.52

TABLE 3

MEAN CORRECT PROPORTIONS ON FIRST RESPONSES TO DIFFERENT LESSON MATERIAL CATEGORIES BY CONCEPTUAL TOPICS

Concepts	Textbook	Films	Conception Exercises	Base-line*
Scientific Measure	.698	.611	.586	.591
Optics and Light	.733	.675	.673	.578
Force and Energy	.706	.547	.666	.483
Electricity	.703	.476	.653	.391
Modern Physics	.703	.486	.605	.412

*Data collected on prior student groups.

TABLE 4

MULTIPLE CORRELATIONS OF LESSON CATEGORIES

WITH EXAMINATION OUTCOMES

	Mid-Term Examination	Final Examination
Textbook	.605	.694
Films	.587	.445
Conceptual Exercises	.870	.901

TABLE 5

COST ESTIMATES OF DEVELOPMENTAL AND

OPERATIONAL ACTIVITIES EXPENSED

BY THE FSU PHYSICS PROJECT

Category	Man Years of Effort	Cost
I. Physics Course Preparation		
Physics Writers	2.0	$ 20,000
Physics Faculty Consulting	1.0	20,000
Films and Audio Preparation	.5	4,000
CAI Coding	1.0	6,000
Behavioral Scientist	1.0	14,000
		$ 64,000
II. Computer Systems Development		
Data Management System	3.0	$ 30,000
Data Analysis Programs	2.0	16,000
Data Analysis Operations	1.0	6,000
		$ 52,000
III. Administration and Services		
Administrator	.5	$ 7,500
Secretaries	2.0	10,000
		$ 17,500
IV. CAI Course Operations		
Proctors		$ 2,500
Physics Tutors		1,200
Computer Operator and Technician		3,000
		$ 6,700
	TOTAL	$ 139,200

Definitions and Examples as Feedback in a

CAI Stimulus Centered Program

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The requirement for correctional feedback to erroneous answers in order to facilitate acquisition has been well established in verbal learning and pedogogical experiments. Unfortunately, the precise form and content for these correctional messages that will maximize learning remains a clouded issue. For the classroom teacher, restating the problem, giving analogous examples, citing the solution rule in a verbal form, or just giving the correct answer are commonly observed. Within the tradition of programmed instructional research, the role of prompts or hints as correctional messages has led to ambiguous findings.

Programmed Instruction (PI) advocates of "Stimulus-Centered Programming" (Klaus, 1965) place a stronger emphasis on correctional procedures for erroneous responses than on reinforcement of correct responses. More currently, authoring within Computer Assisted Instruction (CAI) manifests many of the obvious alternates to correctional approaches.

The present study considers the case for a specific area-proofs in mathematics. Correctional feedback alternatives in this content area are usually a formal definition (symbolic statement of a rule), a verbal definition (an English language form of the formal definition), or a numerical example of the formal definition. The precise nature of the feedback tends to represent the artfulness and style of the course author.

The present study was designed to test the relative efficacy of the latter two feedback modes, verbal definition and numerical example. In addition to assessing the opposed conditions of definition and example, we developed a more detailed CAI program that utilized both message types according to the best intuitions of an experienced mathematics instructor. This combination treatment represents one conception of a conventional classroom approach to mathematics instruction.

In comparing the use of verbal rules and examples as aids in mathematical problem solving, the present study is related to previous research concerned with "inductive vs. deductive learning", "discovery vs. expository learning", and "rule vs. example learning" (e.g., Belcastro, 1961; Gagné & Brown, 1961; Guthrie, 1967; Krumboltz & Yabroff, 1965; Michael, 1949; Scandura, 1964; Sobel, 1954; Worthen, 1967). However, this study differs from them quite markedly in that the "rules" and examples are used solely in CAI-feedback as an aid in justifying the steps in a mathematical proof and not as "the technique" for problem solving.

Jensen (1966) investigated the effectiveness of CAI instructional units involving algebraic proofs. Ss were asked to verify simple algebraic relationships by providing the necessary steps and apply the appropriate axiom to justify each step. One group of Ss was presented with the complete set of axioms to be used in the proofs. They were then shown sample proofs demonstrating uses of the axioms and were then given the task of proving a collection of theorms using the given set of axioms. For the other group, the set of axioms was partitioned into several subsets. For each subset, sample proofs were given to illustrate the application of the axioms in the subset and Ss were required to prove theorems using axioms from the subset before proceding to the next subset. Mean differences for the two groups with respect to program performance scores, posttest scores, and program times were not significant. Large differences between pretest and posttest scores for all Ss indicated that CAI instruction was quite effective in teaching some basic ideas in deductive reasoning. No correctional feedback was used in the Jensen study and Ss were required to construct the steps in the proofs. In the present study, Ss were only required to select the appropriate rule which justified each step in the proof.

Easley, Gelder, and Golden (1964) using the PLATO system at the University of Illinois, developed an ingenious theorem proving program where the student could structure his own proofs by applying a rule which would alter the [illegible] step, changing it to an equivalent form. To our knowledge, no hypotheses have been tested using this program.

In summary, this study was intended to answer the following questions:

(a) Should verbal definitions or numerical examples be used as the form of CAI correctional feedback as applied to steps in mathematical proofs?

(b) Should a CAI instructional unit involving mathematical proofs be structured in much the same way as the classroom unit is developed?

Method

Subjects

Forty-five student volunteers were selected from the ninth grade of two Tallahassee, Florida, junior high schools. There were 18 boys and 27 girls, 14 to 15 years of age. These students had just completed the year-long Algebra I course, and were familiar with the real number system and the concept of a mathematical field for real numbers, including the terminology used in describing the field properties (commutativity, associativity, etc.). No student was familiar with the complex number concept.

Materials and Procedure

Each S was first administered the Reasoning sub-scale of the SRA Primary Mental Abilities Tests--grades 9-12. Next, each S was given a mimeographed list containing 24 brief descriptions of mathematical rules with an abbreviation for each rule. The Ss were told that they would use these rules in responding to questions in their CAI programmed unit. The Ss were familiar with most of the rules and each of these was briefly reviewed by the author of the programmed unit using a blackboard to illustrate the rule when necessary. It was explained to the Ss that the unfamiliar rules in the list would be made clear to them early in their CAI programmed unit. These unfamiliar rules involved the set of complex numbers and were subsequently introduced in the programmed unit.

Using the blackboard, Ss were instructed in the use of the IBM 1050 Terminal (a typewriter-like device) so that they could "sign on" the IBM 1440 System and make responses when directed to do so. Each S was then taken to a terminal and given assistance in "signing on" and re-instructed in the response procedures. The CAI programmed unit was presented to Ss at the terminals. In some cases, due to the length of the unit, it was necessary for Ss to complete

S	da
computer	Correct.
computer	(a+(c+e),b+(d+f)) = ((a+c)+e,(b+d)+f)
S	da
computer	No. Numbers are added two at a time. This rule tells us that it makes no difference which two are added first. Try again.
S	ca
computer	No. Numbers are added two at a time. This rule tells us that it makes no difference which two are added first. Try again.
S	aa
computer	Correct.

Group II - numerical example. The programmed unit was exactly the same as for Group I except that correctional feedback was in the form of a numerical example.

Using the same two steps as in the example for Group I, a typical student-machine interaction for a S in Group II would be as follows:

computer	(a,b) + (c+e,d+f) = (a+(c+e),b+(d+f))
S	am
computer	No. Why does (6,8) + (3,4) = (9,12) ? Try again.
S	aa
computer	No. Why does (6,8) + (3,4) = (9,12) ? Try again.
S	tr
computer	No. Why does (6,8) + (3,4) = (9,12) ? Try again.
S	da
computer	Correct.
computer	(a+(c+e),b+(d+f)) = ((a+c)+e,(b+d)+f)
S	dc

computer 12+(13+14) = (12+13)+14 is an example of what happened. Try again.

S ca

computer 12+(13+14) = (12+13)+14 is an example of what happened. Try again.

S aa

computer Correct.

Group III - detailed program with combination feedback. These Ss received a lengthy introduction to complex numbers which included formal definitions of a complex number and equality for complex numbers. Both of these definitions were accompanied by questions and short numerical problems. There was a detailed review of the field properties for real numbers and a rationale for the necessity of complex numbers as well as a preview of what was to be done in the program. The Ss were asked to respond quite often in this introductory section (29 times). Following incorrect responses in the introduction, the problem was explained, and the answer was given to S. Before each proof was presented, a few short problems and questions attempted to lead S to discover the objective of the following proof. When the definitions of addition and multiplication of complex numbers were introduced, practice exercises were used to allow S to become quite familiar with these operations. There were four exercises in addition and eleven exercises in multiplication. Again, following incorrect responses, the problem was explained and the answer was provided for S. The task of supplying rules to justify steps in the 11 proofs was the same for Ss in this group. However, feedback varied in form between the verbal definition and the numerical example. The form chosen for a particular step was the one expected to be more effective. Verbal definitions accounted for the feedback on 36 of the steps and numerical examples were used as correctional feedback on 28 steps. For a given step in a proof, the feedback was identical to feedback on the same step for either Group I or Group II.

the unit at a later date. This was done within two to five days of the first visit. After completing the CAI programmed unit, each S was given a test consisting of 10 True-False and 10 Multiple Choice questions about the information presented in the CAI programmed unit. Most of the True-False questions were transfer items with a few recall items. Eight of the ten Multiple Choice items were taken directly from a step in one of the proofs from the CAI programmed unit. The other two were a transfer and a recall item. This test had an internal-consistency reliability of .38.

CAI Programmed Unit

The unit consisted of a series of 11 mathematical proofs. These proofs establish that the set of complex numbers under the operations of addition and multiplication is a mathematical field. As each step in a proof was presented, S had to respond by keying in the abbreviation from his list which represented the rule justifying that step. Since there were 24 rules from which to select, the completely naive S had a probability of slightly greater than .04 of keying in the correct rule on his first trial. Following an incorrect response, S was given correctional feedback and asked to try again; if he failed again, he was given the same feedback and asked to try again. This process was repeated until the correct response was entered. With the exception of a few steps where more than one rule was an acceptable response, the naive S who kept account of his erroneous responses increased his probability of success by approximately .04 after each incorrect response. It was hoped, of course, that the correctional feedback would reduce the domain of possible correct responses so that no S would be playing a guessing game. The 11 complex number proofs contained 64 steps; three of the proofs had only three steps and one proof had nine steps. Since a complex number was defined as an ordered pair of real numbers, the rules used to justify the steps in the proofs were largely concerned with the field properties of real numbers and with algebraic operations on real numbers.

Design

The Ss were randomly assigned to one of three CAI instructional treatment groups (15 Ss per group). The three groups differed in method of introductory instruction and in the type of feedback following an incorrect response.

Group I — Verbal definition. The introductory material included formal definitions for: (a) a complex number, (b) equality of complex numbers, (c) addition of complex numbers, and (d) multiplication of complex numbers. A single example illustrated each definition. There was also a brief review of the field properties for real numbers. After the introduction, which took approximately nine minutes of computer time, the 11 proofs were presented consecutively. No review or preliminary information was given between proofs. There were no provisions for the Ss to respond in the introductory section. Ss responded only to steps in the proofs.

An example of two consecutive steps from one of the proofs with several incorrect responses on the part of S follows:

computer (a,b) + (c+e,d+f) = (a+(c+e),b+(d+f))

S ca

computer No. We combined two complex numbers into one complex number. What rule allows this?

S dc

computer No. We combined two complex numbers into one complex number. What rule allows this?

S dm

computer No. We combined two complex numbers into one complex number. What rule allows this?

Results

Performance Differences-Programmed Unit

A repeated measures analysis of variance using errors per step per student as the dependent variable indicated a highly significant group-by-proof interaction (Table 1). Figure 1 shows that most of this interaction can be attributed to the performance of the verbal definition (Group I), and the combination, (Group III). Group differences are not easily discernable in cases involving such large interactions. Therefore, Group III was removed, and another repeated measures analysis of variance (Table 2) indicated a significant group difference between Groups I and II as well as significant interaction.

TABLE 1

ANALYSIS OF VARIANCE-I

Source	df	MS	F
Group (I)	2	64.33	2.91
Proof (J)	10	27.30	9.57 *
Subject within Group (K(I))	42	22.06	
IJ	20	7.71	2.80 *
JK(I)	420	2.84	

* $p < .05$

Fig. 1

ERRORS BY PROOF

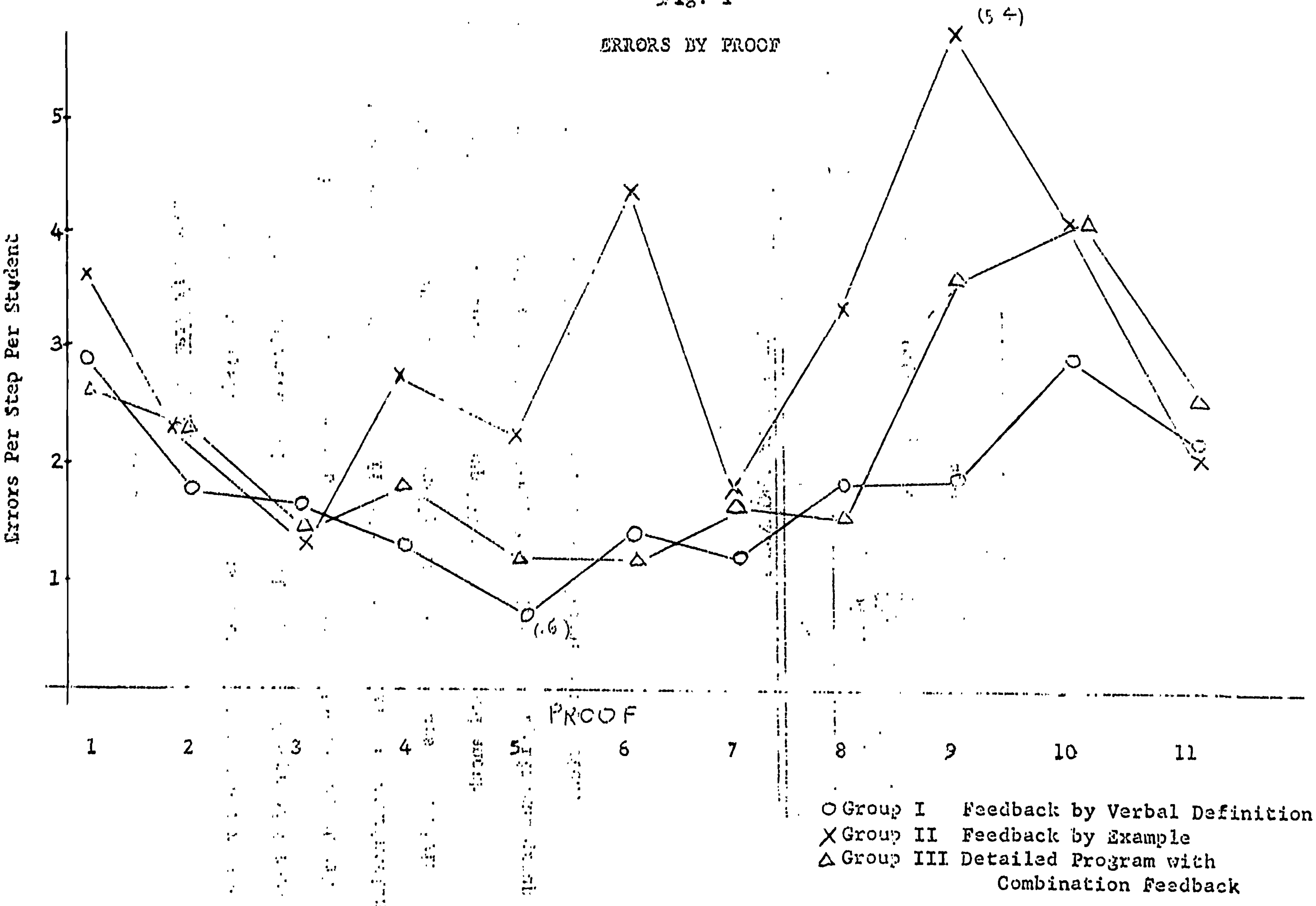

TABLE 2

ANALYSIS OF VARIANCE-II

Source	df	MS	F
Group (I)	1	123.13	4.60 *
Proof (J)	10	19.10	6.37 *
Subject within Group (K(I))	28	26.79	
IJ	10	11.02	3.67 *
JK(I)	280	3.01	

* $p < .05$

A sign test for total number of successes on the first trial for each of the 64 steps in the proofs indicated that Group I was significantly better than Group II ($p < .001$). Many of the first pass successes for Group I came in the last two-thirds of the program. In fact, Group I was greater than or equal to Group II in number of first trial successes on 32 of the last 38 steps. On each of the last six proofs, Group I correctly identified approximately 10% more of the rules on the first trial than did Group II. (Figure 2).

Insert Fig. 2

Average times to complete the program were nearly identical for Groups I and II (Table 3). Group III averaged one hour longer at the terminals because of the more voluminous nature of their program.

Fig. 2

FIRST PASS SUCCESS BY PROOF

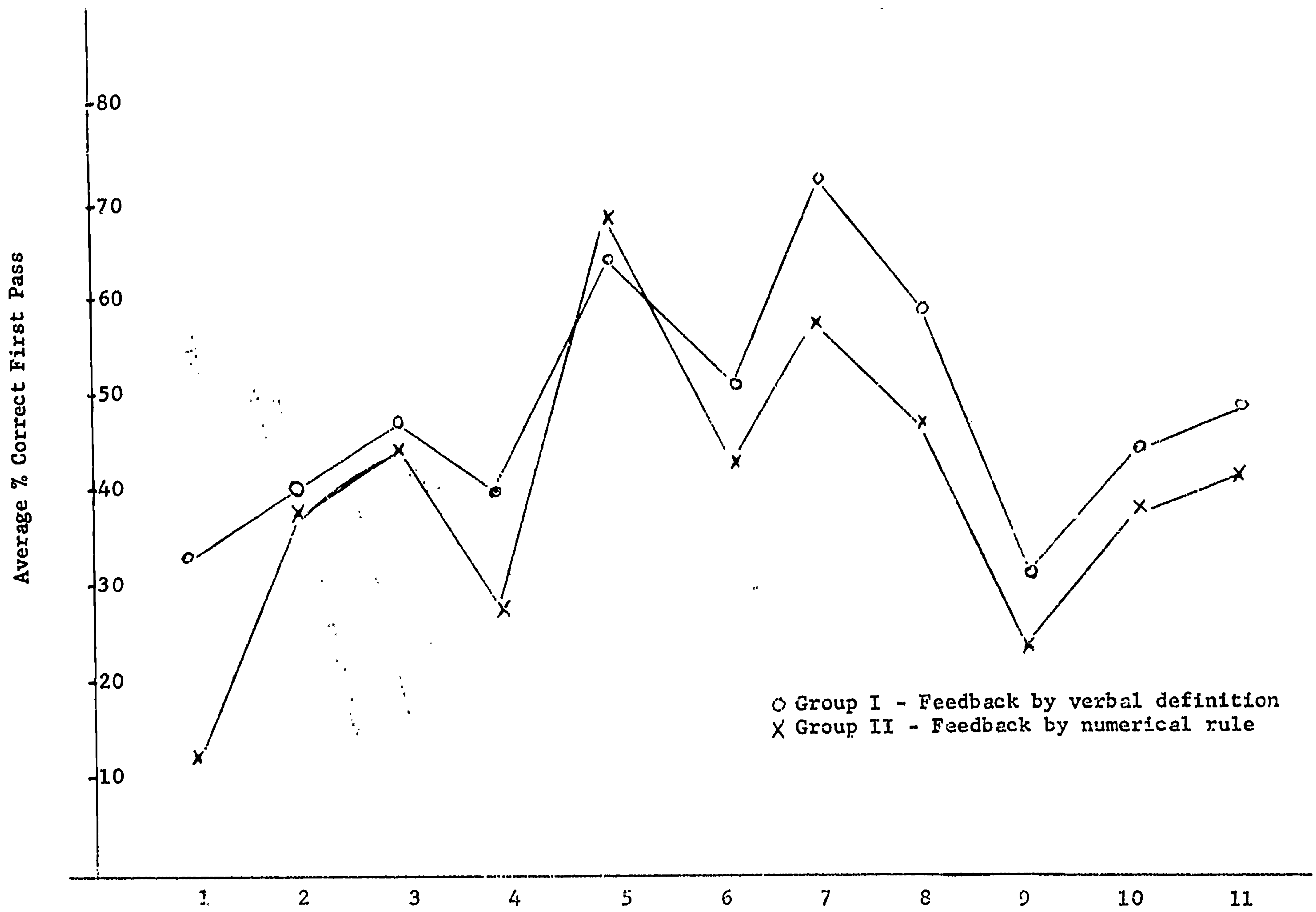

TABLE 3

GROUP MEANS

	Mean Reasoning Score (pretest)	Mean errors per proof per student (programmed unit)	Mean errors per step per student (programmed unit)	Average first-pass success in per cent (programmed unit)	Average time to complete in hours (programmed unit)	Mean Score (posttest)
Group I Verbal Definition	37.5	10.95	1.88	46.6	3.04	11.7
Group II Numerical example	37.9	17.64	3.03	38.0	3.13	10.3
Group III Detailed program-combined feedback	36.2	13.48	2.30	44.8	4.12	11.7

Pre and Posttests

Mean scores for the three groups on the pretest (Primary Mental Abilities Reasoning Scale) were quite similar (Table 3). No significant differences were found on mean posttest scores for the three groups. There were significant ($p < .01$) negative correlations between total errors on the programmed unit and posttest scores for both Group III (-.655) and for all the groups combined (-.429).

Discussion

With respect to CAI presentations of mathematical proofs, it appears that providing correctional feedback in the form of a verbal definition is of more benefit to the learner than using a numerical example. The result is compatable with a finding by Wittrock (1963) which related that giving a rule was more effective than not giving a rule. This result is also in accord with the belief of Ausubel (1963) who states:

> Providing guidance to the learner in the form of verbal explanation of the underlying principles almost invariably facilitates learning and retention and sometimes transfer as well. Self-discovery methods and the furnishing of completely explicit rules, on the other hand, are relatively less effective. (p.56)

Figure 1 indicates that most of the interaction between Groups I and II occurred early in the program- at proofs three and four. This interaction can be explained by an unfamiliarity with the rules- Ss were in a confused state and were applying rules for the first time. As Ss progressed through the last half of the proofs, and rules were reapplied, differences were more pronounced. Given that the learner is in an erroneous state, providing correctional messages in the form of a verbal definition seems to facilitate certain associational mechanisms so that probabilities for success on later trials involving reapplication of the same rule or application of a similar rule are greater. A glance at Figure 2 will support this point as a rather constant probability of success is observed over the last six proofs.

The performance of the group receiving a treatment designed to approximate the classroom approach (Group III) was somewhat below expectations. The longer and more detailed treatment of mathematical proofs within the CAI framework may be unwarranted.

Scores on the posttest were quite low for all three groups (Table 3). The CAI programmed unit was much more difficult than many other CAI programs available for the same age group. The large number of errors made by all Ss was an indication that the unit was also more difficult than other mathematical learning materials to which the Ss had been previously exposed. The small number of items and the extreme difficulty of the test contributed to its low reliability.

The very poor performance of Group II on proofs six and nine (Figure 1) might be explained by the nature of the steps involved. Proof six was the first proof concerned with multiplication concepts. These concepts were not used in the first five proofs. Apparently, the Group II Ss had much more difficulty in adjusting to the transition from the addition proofs to the multiplication proofs. Proof nine was the first proof involving steps where both sides of an equation were operated upon (e.g. multiplication and subtraction of terms on both sides of the equation). It is suspected that the numerical examples were not very effective in illustrating operations performed to both sides of an equation.

The results of a recent study by Scandura (1967) suggest that CAI branching decisions consider more specific forms of response analysis and contingent feedback rather than more general measures such as number of errors, average latency, etc. Scandura advocates a need for determining appropriate feedback in a more efficient manner than what has been done previously. The present study represents an attempt to identify appropriate feedback in a specified area-mathematical proofs.

The effects of feedback by verbal definition seem to vary with the complexity of the learning materials. The results of this study indicate that when the learner is in an erroneous state, providing correctional messages in the form of verbal definitions increases his probability of being removed from that state more than the use of numerical examples. Furthermore, verbal definitional feedback enhances the probability of immediate success on later trials involving re-application of the same rule or application of a similar rule.

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The Development of an Academic Year Institute in Computer-Assisted Instruction

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Background

In progress at the Florida State University in Tallahassee, Florida, is a year-long institute for the education of graduate students in Computer-Assisted Instruction (CAI). This program is funded through Title VI, Part B, Faculty Development Programs, of the Higher Education Act of 1965. The overall objective of the institute is to provide an opportunity for present and prospective faculty to develop an in-depth understanding of all aspects of CAI. The institute began September 15, 1967, and will end June 15, 1968.

As anyone who has tried to recruit faculty in the area of CAI can testify, there has been and is still a critical shortage of adequately trained faculty in this area. It was (and still is) the contention of the directors of this program that the short-course or workshop approach to learning about CAI is inadequate and insufficient. The promise offered by the use of modern digital computing equipment in education is jeopardized by attempting a short-course approach to training personnel in the area of CAI.

Program Objectives

We are therefore attempting to develop this in-depth understanding through a series of theoretical courses offered for graduate credit, individual projects, hands-on experience with computer systems, and close personal interaction between the students and the CAI faculty. The program has been guided by a series of six overall objectives. They are:

1. To acquaint the participants with the field of Computer-Assisted Instruction. This includes a survey of existing electronic equipment, computer languages that operate various CAI systems, and various applications of CAI at the collegiate level.
2. To provide the participants with an understanding of the educational and learning theories that form the basis for the use of CAI. This includes coverage of learning theories, test theory, optimization models, and dynamic programming; and in addition, the interrelationships of learners' aptitude and characteristics and the structuring of collegiate course content in order to best reveal how CAI can individualize instruction.
3. To develop a high degree of proficiency on the part of the participants in the utilization of the FSU Computer-Assisted Instruction systems. This includes an operational understanding of the hardware systems, how they are run, how to program each, and how to obtain sophisticated data analyses.
4. To develop knowledge about the newer techniques of data analysis such as sequential analysis, test of goodness-of-fit for instructional models, and dynamic decision making.
5. To learn how to administer a CAI installation so that the participant will understand the operational factors of cost, time scheduling, course development, and personnel.
6. To author a CAI course segment on one of the FSU systems and to evaluate its efficiency.

CAI Center Facilities

At the Florida State University, the graduate college contains several institutes which are primarily research oriented agencies within FSU wherein faculty members are provided with space and appointments which allow for a maximum of research and a minimum of teaching responsibilities.

History

The Computer-Assisted Instruction Center is a part of the Institute of Human Learning at Florida State.

Computer-Assisted Instruction at the Florida State University started with the installation of a single IBM 1050 typewriter terminal in September, 1964. This terminal was connected by a long-distance dial telephone connection to an IBM 7010 computer at the Thomas J. Watson Research Center in Yorktown Heights, New York.

After a year of operation on this remote basis, an IBM 1440 computer with five terminals was installed in the Computer-Assisted Instruction Center. Several instructional units were developed including the topics of Test Statistics, Chemical Concepts, Modular Arithmetic, Scientific Notation, Prevocational Literacy Training, Concepts of Social Welfare, and Physics.

By September, 1966, the operation of the Center was expanded and additional full-time faculty, Drs. Duncan N. Hansen and Walter Dick, and additional staff was added. A major effort was marshalled toward the development of a college level course in Physics. Additional course materials were developed in the areas of Sequential Testing, Applied Statistics, Computer Languages, and another major project in Junior High Science was initiated.

The faculty and staff were again expanded for the 1967-68 school year when

Drs. Henry T. Lippert and Richard Lee joined the institute, and an additional computer system was installed. This new system, an IBM 1500 Instructional System, provided eight terminals and the expanded capabilities for display, timing controls and response recording over the 1440 typewriter system. By the winter quarter of the 1967-68 school year, this system was expanded to 30 instructional terminals. During this school year, Physics 107 was taught for credit on the 1500 system. Both systems were used by students to review and study physics in preparation for their examinations.

Space and Personnel

The Computer-Assisted Instruction Center is currently located in converted space in the basement of the men's gymnasium. The Center contains approximately 4,100 gross square feet. There are 4 full-time faculty members, 5 full-time professional staff, 12 semiprofessional staff, 3 secretaries, 6 research assistants, 3 student assistants, and 19 graduate trainee fellows--a total of 52 persons in the Center. In addition, there are two complete computer systems which include a total of 36 instructional terminals. Three areas of space are defined for general use, two audio-visual rooms and a duplicating and storage area. Motion picture projectors, tape recorders, dial-access telephones, and laboratory work space are also in use. Supporting equipment for the computers includes key punches and a card sorter.

Selection and Prior Background of Trainees

Subsequent to the announcement of the scheduled institute, approximately 190 inquiries were received. In response, some 109 applications and further information were sent to the inquirers who appeared to be most promising. The Center received 87 applications and of these, 53 were judged to be well qualified for the program. The Center offered admission to 20 of these students and all 20 accepted and enrolled. A total of 39 dependents were included, a ratio of 2 dependents per trainee.

All of the participants had bachelor degrees and 14 held master's degrees at the beginning of the institute. The remaining six will complete the academic work necessary for a master's degree by the end of the summer quarter, 1968. Five of the participants will be completing the Ph.D. degree by the end of the summer quarter, 1968.

Course Work

During the three quarters of the institute, the participants will accumulate 45 quarter hours of graduate course work. Eight courses are required for the trainees and are as follows:

ENR 537, TECHNIQUES OF PROGRAMMED INSTRUCTION; An historical review of the development of programmed instruction and important research relevant to instructional variables is covered in this course. Programming techniques, styles, and methods of course development are covered within the course. Special emphasis is given to author techniques.

ENR 544, ORIGINS OF INDIVIDUAL DIFFERENCES IMPORTANT IN EDUCATION; A survey of biological, psychological, and social origins of individual differences as they apply to instructional problems is given. The application of individual differences especially pertinent to aptitude differences are viewed in terms of educational and instructional strategies.

ENR 565, HUMAN FACTORS IN TRAINING AND INSTRUCTIONAL SYSTEMS; A survey of the systems analysis approach to applied training and instruction systems with emphasis on the inter-relationship among human factors, technological resources, and performance goals.

ENR 538, COMPUTER-ASSISTED INSTRUCTION; A survey of all existing CAI systems is provided and an intensive introduction to the FSU 1440 and 1500 CAI systems is provided as part of this course. The students will learn the operational concepts of the systems and will write programmed materials for the instructional terminals.

ENR 532, COMPUTER ANALYSIS OF EDUCATIONAL DATA; A survey of important developments in research relevant to education which depends on computer data processing. Instruction in the use of multivariate procedures, analysis of variance, and regression analysis is provided and extensive exposure to the FSU Control Data 6400 computer system is included in this course work.

ENR 567, COMPUTER SIMULATION AND INFORMATION PROCESSES OF LEARNING AND INSTRUCTION; Information processing models of associative structures and complex symbolic behavior are considered as prototypes of future educational models. Computer and Monte Carlo simulation techniques are developed.

ENR 556, HIGHER MENTAL PROCESSES; A survey of recent theory and research relating to perceptual and cognitive processes is covered. These behavioral processes are in turn related to the best structuring of educational material at all levels of instruction.

ENR 566, QUANTITATIVE MODELS OF INSTRUCTION; A survey of stochastic processes and dynamic programming are presented as instructional models. Optimization techniques are developed. Applications of multi-stage real-time decision processes within Computer-Assisted Instruction are investigated.

In addition to this course work, frequent group seminars have focused on applicational problems that are most appropriate to developing competencies of an author and manager of a CAI system. These seminars are run on a case-study basis and reflect the individual interests of the participants.

Individual Project

During the first quarter, each trainee defined an area of interest to himself, one in which he wished to develop some materials for presentation by CAI. From these individual projects emerged two major integrated efforts. Each trainee will contribute a portion of one of the total projects.

The first of these projects is the development of a programmed instruction course to teach the author language COURSEWRITER II, used on the 1500 system. A complete Gagné task analysis of the structure of this language was made by one of the trainees. This enabled each trainee interested in this project to choose a portion of the total task and to see how his part relates to the whole project. The trainee who is working on this project is also teaching the portion of the course in CAI that deals with his chosen topic.

The second project deals with the systems approach to education. This course is a multi-level introduction that will allow at the first level a one hour, overall, broad introduction to the systems approach. At the second level the student will be given a detailed presentation of each of the basic concepts requiring about one hour of learning for each concept. The concepts being considered are (a) specification of content, and task analysis; (b) behavioral objectives; (c) sequencing of objectives; (d) assignment of media to objectives; (e) criterion measures and (f) revision procedures. The third level will deal with specific curriculum or administrative areas such as (a) student registration, (b) adult education, (c) in-service education, (d) math education, and similar topics. The student in this course will be able to study systems concepts in depth, across curriculum and administrative areas or will be able to study within these areas across the systems concepts.

Two examples of individual projects warrant some comment and illustrate the kinds of projects on which the students are working.

The first is investigating a linear instructional approach to teaching the subject of curriculum organization. The three organizations are the traditional ones: subject matter, core and activity. The topics have been sequenced on a logical ordering of the concepts for one group. The second group will be taught in a traditional classroom manner. The other group will allow the student to select topics of his choice according to his desire. All the groups will be given information as to how well they performed on a pre-test. This program is being run this week and next on the 1500 system.

The second individual project will automate the routine aspects of academic counseling. The first task of this project was to identify the types of information exchanged between the student and his advisor; the second is to determine what parts could be programmed and the third is to evaluate the effectiveness of the program by actually using it to counsel students. The results will be judged as to its adequacy by a panel of faculty members. This program will be run on the 1440 system.

Future Plans

The trainees are each working on degree programs and will, in nearly all cases, continue through a doctoral program. These programs are in Educational Research, Higher Education, Educational Administration, and in Psychology.

Application has been made for an Institute to be held during the 1968-69 school year. Word has been received that this Institute will be funded.

THE EFFECTS OF VERBAL REINFORCEMENT ON COMPUTER-ASSISTED LEARNING[1]

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The notion of verbal reinforcement (RF) has been in evidence in psychological literature for years, and now with the advent of Programmed Instruction (PI) and Computer-Assisted Instruction (CAI), the implications of this theoretical concept have far-reaching practical significance. The generally positive results of the effects of RF in verbal learning have led programming authors to the foregone conclusion that RF in programming would have a favorable influence on learning. The results to date, however, are not as conclusive as one would expect. The majority of current investigations either conclude or assume that feedback after responses does not seem to be a significant variable in learning (Moore and Smith, 1961; McDonald and Allen, 1962; Hough and Revsin, 1962), although there is some evidence to show that performance in PI is enhanced with feedback and RF (Krumboltz and Weisman, 1962; Krumboltz and Kiesler, 1964; Grace and Cantor, 1964).

Holland (1964) suggested that this inconsistency may be due to the fact that investigators have not looked carefully at questions concerning the

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nature of the RF. Gilbert (1962), for example, has suggested that a student should receive feedback that is particularly reinforcing to him. My investigation sought to examine the effects of five separate feedback conditions in a CAI learning sequence utilizing the programming capabilities of the IBM 1440 instructional system to store idiosyncratic verbal feedback (i.e., specific words) for each of the 75 subjects involved. The unique capability of the CAI system to vary specific segments of course presentation without altering the instructional sequence of the program allowed the five feedback conditions to be tested with identical learning materials. The program, therefore, allowed the students to receive varying degrees of pleasing, personalized feedback following correct responses. To keep from confounding the results with interactive effects of particular types of feedback following incorrect responses, all five groups received identical information after each incorrect response given to a question. This information was in the form of a hint, the correct answer, or a rule--depending on the location of the question in the program--and was usually preceded by the word "Incorrect."

Method

Subjects. For this study, 75 students, 37 boys and 38 girls, were selected from among volunteers in grades nine through twelve from several Tallahassee junior and senior high schools. All students had completed a year-long Algebra I course, and were familiar with the real number system and the concept of a mathematical field for real numbers, including the terminology of field properties (commutativity, associativity, etc.). No student had studied complex numbers in school.

Materials. The first task for each student was to determine his individual preferences for pleasing words. To do this, each student ranked the five most pleasing and the five least pleasing words from a list of 19 positively affective words. In addition, each student was given the option to insert three words of his own if none of the words on the list were particularly pleasing to him.

Each student then took the Mental Reasoning portion of the SRA Primary Mental Abilities Tests, Grades 9-12 (PMA). This portion includes the Letter Series (LS), Word Grouping (WG), and Number Series (NS) tests. Then, all students received a unit on complex numbers which was presented via the CAI system. The unit consisted of a field properties review, definitions of complex number terminology and a section of 11 proofs, in which knowledge of field properties and new definitions was required to justify the steps in each proof.

After completing the programmed unit, each subject was given a test of 10 true-false and 10 multiple-choice items. Most of the true-false items were transfer questions with a few recall items. Eight of the 10 multiple-choice items were taken directly from instructional frames. The other two test items were a transfer and a recall item. The reliability of this posttest was .38. (It should be noted here that the uniformly poor performance on the posttest which contributed to its low reliability was due in part not only to the small number of items but to the fact that the complex numbers materials are considerably more difficult than most of the CAI learning materials we have available. It was felt that differences in RF effects would show up more clearly if the criterion performance for the subjects was not uniformly high.)

Procedure. The students were randomly assigned into five groups of 15 each. Each group was to complete the program described above. During the proof section of the unit, the student had to determine and enter the correct reason for each step in a proof before the next step was presented to him. The student had a list of 24 properties of real and complex numbers from which he selected the correct reason for a particular step in a proof. Therefore, it was possible for a student to make 23 errors before selecting the correct reason for a given step in a proof, and more if he entered a wrong reason more than once. Following an incorrect response, the student was given a hint and told to try again until the correct response was entered. The program was presented at IBM 1050 terminals (a typewriter-like device) through the IBM 1440 system.

Design. The five groups differed only in the type of feedback they received after a correct response.

Group I - Common Reinforcement (CRF). Nineteen reinforcing words or pairs of words were taken from existing programs written by authors at the FSU-CAI Center. These 19 words were randomly programmed to follow correct answers. This condition served as a control group in the sense that the occurrence and nature of these words are representative of those found in a typical CAI lesson.

Group II - High Reinforcement (HRF). For each of these students, counter space was made available in the computer core area to store the three words which he chose from the list to be most pleasing. In this way, these idiosyncratic responses were available for personalized positive feedback to correct responses in the program. The three responses were programmed to be randomly distributed among correct responses in the materials.

Group III - Low Reinforcement (LRF). For each member of this group, idiosyncratic feedback followed correct responses in the same way as described above for HRF subjects. The only difference is that these students received words which they had rated least pleasing from the 19-word list.

Group IV - Knowledge of Results (KOR). This group of students received no reinforcing feedback following correct answers. In place of RF, they received blank counter displays. At the beginning of the program, they were instructed that they would know when they were correct because they would receive either the next question or an instructional statement. If they answered incorrectly, as in the other groups, they would know because they would be given the correct answer or a hint to help them find the correct answer.

Group V - State Reinforcement (SRF). This group received feedback only after every fifth question. At this juncture, they were told how many of the last five questions they answered correctly on the first try. If they answered four or all five correctly, they received the following statement: "You answered 4 (or 5) of the last five questions correctly on the first try. Keep up the good work." If they answered zero or only one, two or three of the five questions correctly, they received this statement: "You answered 0 (or 1, or 2, or 3) of the last five questions correctly on the first try." Those not reaching the criterion of four or five correct did not receive the accompanying RF statement.

Analysis and Results

Four separate analysis of variance (ANOV) designs were applied to the results of the different RF conditions. The four dependent variables examined were posttest scores (PT), total learning time (T), total errors made in the proof section of the program (E), and errors per step per proof. Ability, as measured by total PMA scores from the pretest, was used as a second factor in the first three designs; and errors due to proofs was the second treatment effect in the fourth ANOV design. Each design tested the null hypothesis of no difference in variance due to the two treatment or interaction effects.

ANOV I Reference to Table 1 shows that RF conditions produced no significant differences among posttest scores. The five mean posttest scores for CRF, HRF, LRF, KOR and SRF were 11.8, 11.8, 11.0, 11.6 and 10.7, respectively. Variance due to ability was significant (F = 7.35,

$p < .01$). Mean high ability score = 12.4; mean low ability score = 10.4. Interactions were not significant at the .05 level.

ANOV II RF treatment differences in time on the computer were found to be significant ($F = 3.23$, $p < .025$). A Newman-Keuls sequential range test was applied to the group means; Group 4, KOR, took significantly longer to complete the program than any of the other groups ($p < .05$). The mean time (in minutes) for the CRF, HRF, LRF, KOR and SRF were 276.1, 253.6, 262.9, 316.0 and 269.4. None of the other RF groups were significantly different from each other with respect to time. Ability differences were also significant ($p < .025$) with high ability taking less time than low. The mean time for high ability subjects was 261.7 minutes, and for low ability 289.5 minutes. Interactions were not found to be significant.

ANOV III RF conditions produced no significant differences among total errors in the proof section of the program. The mean errors were 147.6, 134.0, 166.6, 149.1, and 188.9. Significant variance was accounted for by ability level ($F = 8.39$, $p < .01$). The mean time for high ability = 129.0, and for low ability = 185.5. Interactions were not significant.

ANOV IV Errors per step per proof were analyzed to see if an increasing or decreasing trend in error rate might have developed due to RF. There were no significant differences on this variable in any of the feedback conditions. The mean errors per step per proof were 2.17, 2.01, 2.44, 2.53 and 2.91. Variance due to different proofs was significant ($F = 14.52$, $p < .001$). The mean errors per step on the 11 proofs were 3.67, 2.20, 1.58, 2.57, 1.53, 1.53, 2.35, 2.04, 3.14, 3.48, and 2.43, indicating that there were some proofs which were more difficult for the students. However, there were no significant interactions between proofs and groups.

In addition to the analyses of variance, intercorrelation matrices of the following variables were computed for each RF group and for the combined test population: scores on the PMA LS, PMA WG, PMA NS, total PMA scores, posttest scores (PT), T, and E.

These intercorrelations were computed for each group (N = 15) and the combination of all of the groups together (N = 75). For each treatment group (N = 15), correlations of .50 and .62 are significant at the .05 and .01 levels, respectively. For the total group (N = 75), correlations of .23 and .29 are significant at the same levels of confidence. Table 2 shows the degree to which these combinations of variables intercorrelate.

Discussion

Although time does not permit a full discussion of the implications the author has attached to the findings in this study, it is hoped that those interested in such a discussion will request a copy of the full report by mail. In the time remaining, however, I should like to discuss what have been adjudged as some of the more pertinent results.

Analysis of Variance. The results of ANOV II (see Table 1) show that there is a significant difference in the amount of time it took the different reinforcement groups to complete the program. The Newman-Keuls sequential range test showed that the KCR group took significantly more time to complete the program than the other groups. Recalling that blank counters were displayed to KCR subjects following correct responses, rather than RF feedback as in all other groups, it should be noted here that the amount of time required by the 1440 system to search and display counters is the same for those with words as for those without. Hence, the difference in time performance of the KCR group cannot be attributed to any typeout/display time differential. It can be concluded, therefore, that this difference in time to complete the program for the KCR group was due to the peculiar nature of that group feedback condition. And, in fact, KCR was the only group which did <u>not</u> receive some kind of reinforcement after a correct response. This suggests that although the reinforcement conditions did not produce significantly better learning, as measured by the posttest and error rate variables, the subjects in the four RF conditions were more efficient in terms of time required to complete the program. This finding lends support to the notion that Guthrie (1940) puts forth concerning reward. His interpretation of reward is that it protects against unlearning rather than strengthening prior behavior. This complex number program called for repeated use of mathematical definitions and field properties in order to complete the proof sections therein. Students who were not reinforced seemed more inclined to forget the appropriate use of known definitions and field properties than the students who were rewarded. As a result, they appeared to go through a longer search time for the information they had previously acquired each time they needed that information. Consequently, their performance time is slowed; although their actual comprehension does not seem to be impaired.

Correlations. Table 2 shows that in the HRF group, LS, WG, and PMA negatively correlate significantly ($p < .05$) with time for completion of the program. This negative correlation between ability and time suggests that the students who had high ability scores did in fact perform more efficiently in terms of time to criterion. Since this is the only group in which this trend is found, it implies that the HRF condition tended to "spur the students on" even though this increase in speed did not seem to influence learning significantly. This further validates the hypothesis that performance, i.e., time to complete the CAI unit, can be enhanced by RF but that learning, measured by posttest scores and errors committed in the program, is not affected.

The HRF group is also the only individual group which showed a significant negative relationship between WG and E as well as between PMA and E ($p < .05$). This relationship can be accounted for with the hypothesis that performance of high ability, verbally-oriented students is more readily manipulated by verbal reinforcement than is the performance of those less verbally-oriented.

Time to complete the program and total errors were significantly correlated in the HRF and SRF groups (.68, $p < .01$ and .56, $p < .05$). Because a question appears only after a correct answer to the previous problem and, hence, looping continues only as long as the errors are made, it might be concluded that it simply takes longer to finish the program if one is making errors. However, this correlation between E and T did not appear in the combined group correlations nor any of the other group conditions. Therefore, significant positive correlations between T and E for the HRF and SRF groups may imply something about the nature of the behavior process which takes place in a high reinforcement situation for subjects who are not progressing well. Students who are unsure about how accurate their response is going to be may take significantly longer time to make an attempt at being correct in order to increase their probability of being reinforced. This would seem logical since the feedback in the other three groups (KOR, LRF, and CRF) was not designed to be as reinforcing as the feedback in the HRF or SRF conditions.

Conclusion

The results of this study point to the significant influence of RF over simple KOR in CAI learning. The findings demonstrate that the use of reinforcing statements following correct answers is a significant factor in reducing the time students spend on the computer to learn a given set of materials. This reduction in time, however, does not seem to be a detriment to learning. Since computer scheduling and costs are a significant consideration in an ongoing CAI operation, more research in this area is justified to substantiate this likely relationship of RF to learning time with other learning materials and types of programs.

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TABLE 1

ANALYSIS OF VARIANCE RESULTS

(Mean Differences Between Groups, Ability and Proofs)

ANOV I

Dependent Variable: Posttest Scores (Raw)

Group	CRF	HRF	LRF	KOR	SRF	F ratio
Mean	11.85	11.85	11.0	11.57	10.71	< 1

Ability	High PMA	Low PMA	F ratio
Mean	12.4	10.4	7.35 $p < .01$

ANOV II

Dependent Variable: Time to complete program (minutes)

Group	CRF	HRF	LRF	KOR	SRF	F ratio
Mean	276.1	253.6	262.9	316.0*	269.4	3.23 $p < .025$

Ability	High PMA	Low PMA	F ratio
Mean	261.7	289.4	5.36 $p < .025$

ANOV III

Dependent Variable: Total errors in proof section of complex numbers program

Group	CRF	HRF	LRF	KOR	SRF	F ratio
Mean	147.6	134.0	166.6	149.1	188.9	< 1

Ability	High PMA	Low PMA	F ratio
Mean	129.0	186.0	8.39 $p < .01$

ANOV IV

Dependent Variable: Errors per step per proof

Group	CRF	HRF	LRF	KOR	SRF	F ratio
Mean	2.7	2.01	2.44	2.53	2.91	< 1

Proof	1	2	3	4	5	6	7	8	9	10	11	F ratio
Mean	3.67	22	1.58	2.57	1.53	1.52	2.35	2.04	3.14	3.48	2.43	14.52 $p < .001$

*A Newman-Keuls sequential range test showed that KOR differed significantly ($p < .05$) from the other groups which did <u>not</u> differ from each other.

TABLE 2

INTERCORRELATION MATRICES

Group I – Common Reinforcement (CRF)
N = 15

	LS	WG	NS	PMA	PT	T	E
LS	1.0	.11	.26	.70**	-.07	.47	-.06
WG		1.0	.17	.63**	.01	-.10	-.47
NS			1.0	.70**	.39	-.02	-.49
PMA				1.0	.16	.18	-.50*
PT					1.0	.24	-.66**
T						1.0	-.19
E							1.0

Group II – High Reinforcement (HRF)
N = 15

	LS	WG	NS	PMA	PT	T	E
LS	1.0	.12	.41	.71**	.00	-.50	-.27
WG		1.0	-.21	.66**	.49	-.54*	-.61
NS			1.0	.49	-.07	.06	-.08
PMA				1.0	.30	.57*	-.58*
PT					1.0	-.08	-.63**
T						1.0	.68**
E							1.0

Group III – Low Reinforcement (LRF)
N = 15

	LS	WG	NS	PMA	PT	T	E
LS	1.0	.57*	.23	.74**	.03	.06	.24
WG		1.0	.41	.88**	.12	.05	.25
NS			1.0	.70**	.31	.09	-.08
PMA				1.0	.20	.08	.18
PT					1.0	.14	-.72**
T						1.0	-.03
E							1.0

Group IV – Knowledge of Results (KOR)
N = 15

	LS	WG	NS	PMA	PT	T	E
LS	1.0	.29	.57*	.93**	.36	.10	-.37
WG		1.0	.17	.52*	.26	-.49	-.08
NS			1.0	.75**	-.06	-.11	-.51*
PMA				1.0	.29	-.10	-.44
PT					1.0	.09	-.40
T						1.0	-.08
E							1.0

Group V – State Reinforcement (SRF)
N = 15

	LS	WG	NS	PMA	PT	T	E
LS	1.0	.08	.54*	.75**	.28	.15	-.22
WG		1.0	.09	.69**	.32	-.29	-.13
NS			1.0	.61**	.00	.14	-.22
PMA				1.0	.35	-.05	-.26
PT					1.0	-.45	-.30
T						1.0	-.56*
E							1.0

Total Groups
N = 75

	LS	WG	NS	PMA	PT	T	E
LS	1.0	.19	.37**	.78**	.16	.07	-.1[illegible]
WG		1.0	.05	.66**	.26*	-.20	-.2[illegible]
NS			1.0	.61**	.10	.02	-.2[illegible]
PMA				1.0	.26*	-.06	-.3[illegible]
PT					1.0	.02	-.5[illegible]
T						1.0	-.[illegible]
E							1.[illegible]

Note: * p <.05 ** p <.01.

LS: Primary Mental Abilities Letter Series; WG: PMA Word Grouping; NS: PMA Number Series; PMA: Primary Mental Abilities Total; PT: Posttest Score; T: Time to complete Complex Numbers Unit; E: Total Errors committed in program.

COMPUTER AUGMENTED PLACEMENT SERVICE

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__The Problem.__ The modern college placement office is charged with a threefold responsibility: provision of services to its registrants, services to employers, and information services to the parent institution. The ability to discharge these responsibilities is becoming increasingly difficult, even in relatively small institutions. The burgeoning number of employers seeking talent, and the heightened awareness of the services available to an ever growing number of graduates, are seriously taxing budget and personnel resources.

At the same time, there is a continuing national emphasis on the conservation and development of human resources. This draws attention to a dimension of job selection which places increased emphasis on employer-employee matching to provide work environments conducive to productivity and success. Further, this emphasis suggests the long-term involvement of placement officials in career development.

As the number of registrants and employers grows, the placement officer is required to devote more time to routine administrative matters and counseling with students is moved further into the background. When the placement officer loses contact with registrants, his ability to provide follow-up services is seriously decreased. Similarly, administrative and clerical burdens limit time available for consultation with potential employers to bring about their active involvement with the placement office.

The most desirable situation is one in which the qualifications, aspirations and specific needs, of both employer and registrant, are immediately available to interested parties without a time-consuming manual file search. Furthermore, there must be efforts made to match a registrant to positions on the basis of criteria which would be indicative of his success in the positions. These are most reasonable tasks for electronic data processing.

Rationale for the Study. It is somewhat surprising to note the limited utilization of automated techniques by university placement offices. This is particularly true when one notes how well the activities of any placement organization lend themselves to machine accounting routines. The literature in this area, as we have seen, is scanty. Still, it spells out explicitly and implicitly the potential of such undertakings. Yet, only a handful of placement offices have embarked upon various kinds of machine accounting, and even fewer have given any thought to computer involvement. Of the latter, Arizona State, Illinois, and Wisconsin, joined now by Florida State University and North Carolina State University, seem to have generated the most inclusive thrust.

Perhaps this condition is related to limited finances, time and the talent which must be diverted to accomplish such a task. Too, the long range availability of technically skilled people and the organizational preciseness required tends to slow the progress of even the most ambitious placement executive and his administrative hierarchy. More likely, it is a combination of these factors, coupled with a group of worthy options which lessen determination to accomplish this task. Endless controversy on centralization versus decentralization of placement services retards development and expansion efforts. In addition, it tends to undermine imaginative organization and procedural patterns which, though initially expensive, hold promise for systematic interaction between employers and employees. Deliberation on fee versus no fee and departmental or divisional user financing versus central administration financing keep optimal fiscal support waiting in the wings. Long range commitments versus a "one-shot" job contact influence the personnel and economic posture of the Placement Office. Of course, the latter approach makes it impossible to develop service potential as a data bank and information retrieval center for curricular analysis and human factors research.

Furthermore, there is an overriding uncertainty as to whether universities, faced with a variety of institutional commitments and numerous forces competing for financial support, should even be in the placement business. Some argue the functions could best be performed by state employment services and/or private agencies. Surely, this honest difference in philosophy has tended to undermine dramatic action on the part of placement officers who might otherwise have committed funds to prove the uses of these more sophisticated tools. Perhaps they might even have blazed some trails of career planning and of human resource engineering.

While it is true that public and private agencies have made a most promising start in the use of modern technology for placement functions, there is some indication that vast numbers of professionals will shy away from these activities because they are fee-charging and because they have some of the same historical stigma that surrounds commercial employment agencies. In addition, heretofore mentioned philosophical and practical objections plague the United States Employment Service, and it appears that they are of sufficient magnitude to make it unlikely that this agency will advance in computerized placement services for professional school graduates in the foreseeable future. Furthermore, these groups can give little thought to information needs and to potential data bank research at the institutional level.

Thus, it seems to the investigators that professional organizations such as CPC, ASCUS, and NEA will do much to advance the state of the art and the development of systems compatibility. The employment service will fill the void, in a traditional sense, in those instances where univerisities neglect or abandon their placement function. Yet, there remain imaginative new roads for placement offices which are adequately financed and philosophically committed to the exploration and development of such programs.

The Matching Concept. The concept of the matching program is direct in approach and practical in design. Basically, it is a rapid file search to locate individuals or positions, based on quantifiable parameters which relate to a success environment.

The matching process is a simplification of the mental processes used in manual matching of persons to positions in placement activities. When a manual search is initiated, placement personnel keep in mind certain gross boundaries which serve to eliminate or to include persons or positions depending upon which is sought. The present system establishes these boundaries on the basis of information supplied, and it systematically eliminates or includes file records.

The purpose of utilizing machine processing for this task is to let the machine do the "paper-shuffling" (which it can do rapidly and efficiently), thus releasing staff personnel to do essential career counseling and administrative work. The load of paperwork which attends the functioning of a placement center is tremendous; by placing the organization and the filing of certain positions on established machine procedures, it becomes mostly a clerical operation which may be handled by less-skilled personnel.

Philosophical Framework. The system developed for this pilot study may be thought of as "inclusive" in that it makes a concerted effort to get a maximum number of potential employees and employers into contact with each other. While it does accept or reject registrants on certification factors, geographic limitations, teaching level categories and citizenship requirements, it is felt that these factors are essentially set by overriding professional considerations, system acceptance of several personal choices, previous training and state or local regulations. Varieties of other items are included for priority ranking purposes and are intended to help interested parties proceed through a systematic screening process. Thus, we have hoped to obtain maximum contact, within discrete limitations introduced into the job description and/or the employee's desires. For example, we assume the integrity of an employment official's request for a senior high school (10 - 12) biology teacher in a specific community. Our responsibility becomes one of finding as many persons appropriately trained for this level and willing to accept the geographic area on a first, second, or third choice basis. English teachers (even those who might be willing to give biology a whirl) and junior high general science persons will, indeed, be excluded.

When computer "matches" have been obtained on these minimal requirements, other important ingredients (special curricular teaching, extra-curricular responsibilities, cultural environment, and the like) become the prerogative of employment officials and the potential employee for consideration and negotiation.

The system is presently limited to professional education employment opportunities. This was done to facilitate the development and control of matching variables, the availability of a large pilot group and a wide variety of reported employment opportunities. At the same time, the study was done with an eye toward easily prepared auxiliary programs for all placement office registrants.

A word should be said about the fiscal philosophy which underlines the study. In the best sense, it is not intended to be a self-supporting, job-seeking machine service. Persons could readily be charged for entry into the system. Indeed, finding our students jobs with suitable employers through orderly and sophisticated procedures is an immediate, legitimate goal of the system. Nevertheless, this, alone, is below the expectation of the investigators and the potential of the tools involved. To us, the large university placement office of the future will become a repository for data on the institution's graduates for location and follow-up studies, research in employment patterns, and evaluation. In this light, it becomes a unique component of research activities attacking the elusive variables of career choice, career planning, and the optimal utilization of human resources. Allowing this possibility, one becomes less enamored with a fee-for-the-service approach to financing. Quite to the contrary, one begins to explore means of bringing all of our graduates into the system and maintaining contact with them over a period of years so that they are a readily available source of information for continued analysis and evaluation.

It cannot be emphasized too strongly that the machine process is intended to augment rather than replace established placement procedures. The human relations aspect of placement is tremendously important. Proper career counseling involves a face-to-face relationship which cannot be assumed by machines, no matter how sophisticated the programming. Nothing about the system described here is intended to be "final"; rather, the output from the program should be considered only as "suggestions" which the computer makes on the basis of available -- and admittedly incomplete -- information.

<u>The Job - Seek - Person Procedure</u>. This procedure is followed whenever a job has been listed, and an individual is sought who can reasonably be expected to fill the position. The agency listing the position with the placement office establishes the boundaries through the information supplied on the vacancy listing form. This data may be operationally divided into two categories: match parameters and information parameters.

Information parameters are items of information which are supplied to potential candidates for their own use in judging the position which is reported to them. These do not establish boundaries for the machine, but they may cause the candidate to reject the position, or to place it in a low category. However, they may also have the opposite effect -- to place it in a higher priority. In any event, they do not enter the machine match but simply appear as items on the hard copy received by the candidate. Examples of items which may appear as only information are "Rural School," "BSCS Classes," "Team Teaching," etc.

Match parameters are chosen broadly to conform to areas within the concept of "success environment" and to establish those boundaries around the position which would exclude persons not qualified for, or not desiring positions which are thus described. The definition of a success environment (in which employer and employee are happy with each other) must include these parameters. Other parameters, not directly related to the success environment, are also used in establishing these boundaries. The employer may specify a requirement for a master's degree, which would eliminate all who did not hold this degree, no matter how well qualified otherwise. The employer may specify that the applicant be female, for example, in teaching positions in physical education, which would, of course, eliminate all male candidates.

While salary is a parameter closely associated with the success environment, it was decided that this should remain as an information item on this program. Studies undertaken by the Placement Office indicate that salary is relatively low in the priority of reasons for accepting certain positions. In addition, in education at least, salary is implicit in the stated geographic location preference.

The reasoning here also takes into account the fact that every system has a somewhat different salary scale. The increments, or steps along this scale, vary considerably in amount as well as in the methods of attainment. It was considered that although salary could easily be used as a boundary factor, the range of preparation of teachers, as well as the multiplicity of salary schedules, would prohibit a meaningful evaluation of where an individual would fit on any given scale. Therefore, it was decided that the minimum salary for the position would be reported and that the individual receiving the notification would decide whether or not to pursue the position further.

The operation of the program is straightforward. The position is brought into the machine's memory, and the person file is scanned for an individual who is (or will be) qualified in the area required. When such an individual is located, the geographic location preference of the individual is checked against the position location.

The geographic location is a coded parameter which consists of (1) a broad geographic region; (2) a state; and (3) a region within that state. The code is designed to provide several degrees of generality of inclusiveness. If the state code refers to Florida, the region code indicates a county or one of nine arbitrarily assigned regions of Florida. Other state codes contain a region code only if one of the standard metropolitan areas, designated by the Bureau of the Census, is specified. (The two metropolitan areas of Florida are not included.)

The individual may select three geographic location preferences, in descending order of priority. The program compares first the broad region to the candidate's first preference. If there is a match, the program continues to the state preference. If there is a match, the program next compares the county or metropolitan area. If a match occurs, the program seeks the next match parameter. If no match occurs on the candidate's first preference, the program continues to the second and third. If no match is found, the record is discarded and the next record in the proper certification area is sought.

The candidate may be as specific in stating his preference as he wishes. He may indicate only one very specific preference, or he may wish to show three very general preferences. In the former case, he would never be notified of a position from any county or state unless the exact location were entered into the system. In the latter case, for example, if the candidate specified (generally) the southeastern U.S.A., he would be notified of all appropriate positions (up to an arbitrary maximum) within the geographic area.

The final match parameter is position type--that is, elementary, intermediate, junior high, etc. The code for this parameter is inclusive and allows a great deal of generality. For example, the candidate may specify "elementary" in which case he would be notified of appropriate positions in grades 1 - 6; or he may specify grades 4 - 6, which would eliminate all primary positions for which the candidate may be otherwise qualified.

If a successful match is obtained on all match parameters, the machine prepares an output record containing all information items which are utilized in preparing notifications to the persons.

A simple computational procedure allows program evaluation of the candidate's geographic preference and position-type preferences. A comparison of priorities on the three geographic locations and the two position-type preferences produces a 1-digit code which is used to assign a value to a particular successful match. After all output records are prepared for a candidate, the priority values thus produced are used in determining the maximum number of notifications to be sent. For example, if a maximum of 10 notifications is to be allowed, the 10 records carrying the highest priority values will be sent, while any remaining ones will be discarded.

The Person - Seek - Job Procedure. This procedure is the obverse of the Job-Seek-Person Procedure. The same matching parameters are used to establish boundaries for inclusion. Here, the person's record is entered into memory, and the file of available positions is scanned for appropriate positions. The geographic location and type-of-position preferences are evaluated in the way described above, and an output record is written.

The two match procedures are not separate programs, but are integral parts of one program. In addition to a periodic run-by of all active candidates, provision is made for processing individual entries to the system. Individual candidate or position information is punched into cards, which are then read on the card-reader for processing.

The Output Program. In view of the serious output-bound status of the IBM 1440, it was decided that match program output would be recorded on disk for later preparation.

This approach allows much information to be recorded in a coded form, with table look-up procedures to supply the appropriate literal output.

The output from the Job-Seek-Person Procedure is in the form of a list which can either be forwarded intact to the employing agency, or edited and revised by the Placement Office staff prior to forwarding. The list would contain biographical information on each candidate, certification and experience data, and special preparation of interests which might be of value to the employing agency.

Output from the Person-Seek-Job Procedure would take the form of a notification to the person, stating pertinent information about the job and giving the name and address of the contact person at the employing agency.

The match program contains provisions for an arbitrary maximum of notifications. This provision eliminates further notification to either persons or employing agencies unless feedback is received on action taken on previous notifications.

File Maintenance. Although file maintenance procedures are beyond the scope of this pilot project, certain provisions have been included for ease in later programming. Each candidate record contains 10 positions, or "switches," which can be used for various identifiers. In addition, provision is made to record the number of times each record is matched for notification.

Whenever a record is matched for notification, the current date is entered in the record. If no feedback is received and recorded via the maintenance program for two months, the record is inactivated and will not be available to the match program. Deletion cutoff dates have not been established, but the maintenance program will provide for deletion of a record after an extended period of inactivity. Two types of inactivity are recognized: "updated inactivity" in which the candidate has notified the Placement Office that he is not seeking a position but wishes to remain resident on the files and "regular inactivity" in which the candidates supplies no information. The latter will be routinely deleted.

The file maintenance program will provide for the addition of candidates and positions to the respective file on a batch processing basis.

Program capabilities will provide for updating of active and inactive records to include current employment. Biographical information and other items of the registrant's record also may be updated with this program.

The job file will also be maintained with this program. Jobs which have not received any references will be deleted periodically, and jobs which are reported filled will be deletable through the console (although not physically removed from the file).

The physical deletion of both candidates and positions will occur when additions are merged into a new disk file on a periodic basis. In other words a disk-to-disk transfer, with margin of all records in the add area and deletion of all tagged records, will be performed as necessary.

Conclusions. From the system's logic, from the program developments and from the computer demonstrations, it may be concluded that the Florida State University Placement Office can successfully incorporate electronic tools into the registrant-employer assistance function. These tools can improve and extend the capabilities of manual search and, at the same time, free the placement officials to perform their professional functions of interpretations, explanation, planning, career counseling, coordination, and so forth.

As to the reporting and analysis function for our institution, the placement officer will have access to an orderly system, including retrieval characteristics in keeping with existing reporting demands. In addition, the system is "open-ended" to allow for immediate and continuous reevaluation of information storage, reporting capabilities, follow-up techniques, and employment analysis.

While economic considerations might be important to some institutions considering the implementation of such a system, it appears to the investigators that, economically, it is not feasible to consider anything less at Florida State University. Clerical support for the system (coding and key punching) can be accomplished within the projected secretarial workstudy manpower available to the Placement Office. Technical assistance and computer time should be budgeted initially by the central university administration with the strong prospect that research activities and cooperative projects with business, industry, and educational agencies will provide for these services at minimal costs to this institution.

The parameters for mechanized matching are appropriate to the pilot study. Their expansion to include all segments of placement activities is well within the system's capabilities.

Data collection forms have been revised in keeping with the matching format and are, at the same time, compatible with procedures for a manual search.

STATE ANXIETY AND TASK DIFFICULTY USING CAI MEDIA

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Studies concerning the effects of anxiety on learning have, in the past, originated either from artificial laboratory situations or realistic but poorly controlled naturalistic settings. The laboratory tasks which have been used include paired-associate learning and concept formation studies while the natural-setting experiments have concentrated on such things as the academic performance of students. Computer-Assisted Instruction (CAI) systems provide a learning setting in which it is possible to obtain a detailed analysis of the learning process with materials that are relevant to the real-life needs of the subject. The CAI setting would appear to be especially appropriate for investigating the effects of anxiety upon the learning process in a more systematic manner than has been possible to date.

In studying the effects of anxiety on learning, there is ambiguity in the concept of anxiety that must first be clarified. Spielberger's (1966) State-Trait Anxiety theory distinguishes between anxiety as a transitory state and a relatively permanent personality trait. State Anxiety (A-State) is characterized by feelings of apprehension and heightened autonomic nervous system activity that varies in intensity and fluctuates over time. Trait Anxiety (A-Trait) refers to individual differences in anxiety proneness, that is, differential tendencies among individuals to respond with A-State to situations that are perceived as threatening. This anxiety proneness or trait predisposes an individual to see certain types of situations as dangerous, particularly situations that involve a threat to the individual's self-esteem.

To study the effects of anxiety on learning, a theory of learning is needed which specifies the complex relationship between anxiety and learning. According to the drive-theory proposed by Spence (1958) and Taylor (1956), the performance of high anxious students would be inferior to that of low anxious students on complex or difficult tasks in which competing responses were stronger, and superior to low anxious subjects on tasks in which the correct responses were dominant relative to incorrect responses. Support for this relationship is reported by Spence (1964) in eyelid conditioning by Spielberger and Smith (1966) using serial learning, Weitzmer(1963), using paired-associate learning, and by Denny (1966) using a concept formation task.

The present study will investigate the effects of anxiety on performance on a CAI learning program that is divided into difficult and easy sections.

It was hypothesized that subjects would respond to difficult CAI materials with increases in self-report and physiological measures of A-State. In other words, it was expected that A-State measures would increase during the difficult part of the program and decrease during the easy section. With respect to the effects of A-State upon performance, it was hypothesized that subjects who were high in A-State would make more errors than subjects who were low in A-State on the difficult task, and that the relationship would be reversed on the easy task. The State-Trait Anxiety Inventory (STAI) (Spielberger, Gorsuch, & Lushene, 1967) was used to assess A-Trait and the phenomenological aspects of A-State; systolic blood pressure was employed to measure the physiological aspects of A-State.

Method

Subjects. The subjects were sixteen male and thirteen female undergraduates who were enrolled in the summer session of the introductory psychology course at Florida State University. In order to satisfy a balanced designed criterion of the Biomedical Computer Programs (Dixon, 1967), three male subjects were dropped from the data analysis; the two male subjects with the highest A-Trait scores were dropped so as to maintain equal mean scores for both males and females. And, finally, another male subject was dropped as his total errors on the easy section were five standard deviations from the mean.

Apparatus and Program Description. A CAI typewriter terminal using an IBM 1440 System (IBM, 1965) presented the learning materials and recorded the subjects' responses. Blood pressure was measured by means of a desk model Baumanometer model 300. The STAI measured both trait and state anxiety.

Psystudy, a CAI program used in this study was written in a linear format using COURSEWRITER I (IBM, 1965), an author programmer language. This program was composed of two main parts:

the difficult section, requiring the subjects to prove the field properties of complex numbers; and an easy section that consisted of problems on compound fractions.

The programming logic required the subject to solve one problem correctly before he could attempt the next one. After the first five correct problems on each section, a short anxiety scale was presented. In the difficult section, four different items from the STAI were used; in the easy section four items were used, for a total of eight items. These items were chosen on the basis of highest validity coefficients derived from Hodges (1966). Two representative examples will be given to demonstrate the type of material that a subject was expected to master in each of the two sections.

Difficult Materials Example: The computer would present to the student a series of definitions concerning the field properties of complex numbers and then step 1 of Figure 1. As can be seen

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Insert Figure 1 about here

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in Figure 1, the problem is first presented and then, as in proofs of geometric theorems, a statement is presented for the proof (Step 2). From a sheet listing the field properties of complex numbers with appropriate abbreviations, the subject selected and typed his answer. If he typed in the correct answer (Step 3), in this case S (substitution), the computer would respond "correct" and go on to the next problem. If the subject, however, responded incorrectly, he would be given another example of the principle (Step 4) and told to try again. The subject would continue to respond to this item until he entered a correct answer.

Easy Materials Example. The computer would first type the material presented in Step 1 of Figure 2. The subject was then expected to answer correctly Step 2. If the subject typed the

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Insert Figure 2 about here

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correct answer (Step 3), the computer responded "good" and proceeded to the next question. If the subject responded incorrectly, Step 4 was presented. The student continued to respond until he emitted a correct answer.

Experimental Design. The experiment was divided into four periods: Pre-Task Period, two Performance Periods (Difficult and Easy) and Post-Task Period. The procedures for these periods were the same for all subjects. During the Performance Periods, the subject first progressed through the difficult learning materials, and then the easy learning materials. The A-State measures, SBP and STAI A-State, were taken at the end of each period. Measurement of SBP always preceded the administration of the STAI except during the Pre-Task Period when SBP followed the STAI. In addition, a short anxiety scale was inserted in the two Performance Periods.

The experiment was conducted by two experimenters and up to eight subjects could be run at the same time. The design of the experiment minimized the possibility of any systematic influence due to experimenter since all anxiety measures were taken blind and no experimenter took a complete series of anxiety measures on any single student.

Procedure. Subjects were seated at a CAI terminal, each of which was located in a sound-deadened, air-conditioned room. The subject remained in the room for the entire experiment. The experimenter entered the experimental room only to read instructions, administer the anxiety scales, and assess blood pressure.

Pre-Task Period. Each subject was asked to read an introductory booklet that contained instructions for inducing mild stress as well as directions for operating the terminal. The stress instructions were:

> It has been found that success in this program does not require mathematical or quantitative ability. . . it requires instead, the ability to make the same kinds of abstractions and generalizations that you are expected to make in many college courses.

After reading the instructions, the S called an experimenter by means of a buzzer. Then the STAI A-Trait scale was administered with instruction to indicate how "you generally feel." Following this scale, the subject was given the STAI A-State scale with the instructions to indicate how "you feel right now, that is, at this moment." Each of these scales required the subject to respond in a STAI test booklet. To emphasize the differences between instructions, an experimenter read them aloud to the subject. Upon completion of the STAI scales, the subjects' blood pressure was taken, four to eight times until it had been stabilized (two readings in a row, not differing by more than 2 mm. of mercury). After each reading, the blood pressure cuff was removed so Ss could operate the terminal.

Difficult Performance Period. The subjects then started the difficult section of Psystudy. After he had responded correctly five times, a four item anxiety series was presented by the computer (How did you feel when you were working on the complex numbers?). When the subject had completed this anxiety scale, he continued through the remaining items of the difficult section. At the end of this section, SBP was taken once by an experimenter and the STAI was administered under retrospective state instructions. An experimenter read the following state instructions:

> Fine. Now I want you to fill out this questionnaire again. This time I want you to circle the appropriate number to indicate how you felt while you were working on the complex number program. Read each item carefully and check it according to how you felt (this word was emphasized by an experimenter) while working on this program.

The subject responded in the STAI test booklet.

Easy Performance Period. The easy section of Psystudy was then begun by each subject. A four item anxiety scale was again presented by the computer after the subject had responded correctly five times. These four items differed from those items presented in the Difficult Performance Period. The subject continued the program until the easy section was finished. At this point, an experimenter took the subject's SBP once and the STAI was administered again under retrospective state instructions. An experimenter read the following instructions:

> Good. Now I want you to circle the appropriate number to indicate how you felt while working through the compound fraction program. Remember, respond to each item according to how you felt while you were working on the fraction program.

The subject again responded in the STAI test booklet.

Post-Task Period. Following the administration of the STAI in the Easy Performance Period, the subject was asked to wait three minutes at the terminal and was told that after a brief period, his blood pressure would again be taken. SBP was measured and the STAI was given under standard state instructions after this three minute waiting period. The subject was then asked for his biographical data, including number of math courses he had taken previously. After this information was collected, each subject was debriefed.

Results

The dependent variables in this study were STAI A-State Scores, SBP measures and errors on the Difficult and Easy CAI tasks. The effects of experimental conditions on each of these measures was evaluated in an analysis of variance design in which Task Periods and Sex were the independent variables. Errors were further examined as a function of STAI A-State scores.

STAI A-State. The mean A-State scores for all subjects in the Pre-Task Period, the two performance periods, and the Post-

Task Period are presented in Figure 3. It may be noted that the

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Insert Figure 3 about here

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the STAI A-State scores increased from the Pre-Task Period to the Difficult Task Period, decreased in the Easy Task Period, and showed no change from the Easy Task Period to the Post-Task Period. These data were evaluated in a two-factor analysis of variance of design. In this analysis, Tasks-Periods was the within-subjects variable and Sex was the between-subjects variable. Only the main effect of Tasks-Periods was significant ($F = 13.448$, $df = 3/72$, $p < .001$), indicating that the STAI A-State scores differed over the four periods and that there was no difference in mean A-State scores for men and women. Differences between mean A-State scores for each period were evaluated by t tests. These analyses indicated that mean A-State scores in the Difficult Task Period were significantly different from all other periods ($p < .05$) and that mean A-State scores in the Easy Period were significantly different from the Pre-Task Period ($p < .05$) as well as the Difficult Task Period ($p < .05$). No other analyses were significant.

<u>Systolic Blood Pressure</u>. The mean SBP values obtained in the periods corresponding to those for which STAI A-State measures were available are presented in Figure 4. The mean SBP increased

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Insert Figure 4 about here

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increased during Difficult Task Period, decreased during the Easy Task Period, and showed no change from the Easy Task Period to the Post-Task Period. Both main effects obtained from the two-factor analysis of variance were significant; Sex, (F = 11.44, df = 1/24, $p < .01$) and Tasks-Periods (F = 8.54, df - 3/72 $p < .01$). These results indicate that SBP reliably changed over the Tasks-Periods and that, in addition, males and females differed in their SBP response. Differences between mean SBP scores across periods were evaluated by t-tests. These analyses demonstrated that SBP scores taken in the Difficult Task Section were significantly difficult from all other conditions ($p < .05$). No other comparisons were significant.

Errors with CAI Tasks. Both performance periods were divided into two sections. The first section of the Difficult Task Period consisted of the first five items (proofs), Diff/(1-5); the second section consisted of the remainder of the items Diff/(6-17). Similarly, the Easy Task Period was subdivided into two sections; Easy/(1-5), and Easy/(6-16). The four-item anxiety scale followed the first section in each Task Period. The mean number of errors per item for the first and second sections of the Difficult and Easy Tasks are presented in Figure 5. It may be noted that the mean errors per item is the greatest for the Diff/(1-5) section, at an intermediate level for Diff/(6-17) and that errors fall to almost zero in Easy/(1-5) and Easy/(6-16) tasks. Errors were evaluated in a two-factor analysis of variance with Sex the between-subjects variable and type of section as the within-subjects variable. Statistical significance was obtained only for type of section (F = 20.71, df = 3/72, $p < .001$) which demonstrates that mean errors changed across the four Performance Periods. There were no significant differences in mean error scores for men and women.

Relation of A-State and Performance. Since there were no significant Sex effects in the analysis of the effect of experimental conditions on A-State (STAI) scores nor for errors on CAI tasks, the data for both sexes was combined in order to evaluate the relationship between A-State (STAI) and errors. Separate analysis for the Difficult and Easy Tasks were run because the levels of A-State (STAI) on the Difficult Task were significantly higher than on the Easy Task. Subjects' scores on the STAI (A-State) were divided at the median into two groups. Subjects above the median were designated as High (Hi) A-State and those below the median as Low (Lo) A-State.

The median A-State (STAI) score for the subjects in the Difficult Task Period was 43. Since the scores of two subjects fell on this median, both subjects were dropped from this analysis. Figure 6 shows that the Hi A-State subjects made about

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Insert Figure 6 about here

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1 1/2 times as many errors per item in Diff/(1-5) Task than

Lo A-State subjects, but had fewer errors in Diff/(6-17). The interaction between state anxiety and Task-Period was significant ($F = 5.08$, df = 1/24, $p < .05$) as was the main effect of Task Periods. ($F = 6.59$, $df = 1/22$, $p < .05$). The interaction suggests Hi A-State produced a large number of errors on the Diff/(1-5) task and lead to fewer errors on Diff/(6-17). The Hi A-State and Lo A-State subjects were not significantly different from each other in age, number of math courses, aptitude or mathematical ability, as determined by t-tests. However, the Hi A-State and Lo A-State did differ on Trait Anxiety ($t = 3.84$, df = 22, $p < .001$). The mean A-Trait scores were 39.67 for Hi A-State subjects and 30.5 for Lo A-State subjects.

Similar to the previous example, subjects' scores on the STAI A-State administered after the Easy section were divided (median = (32)). Since four subjects' scores fell on this medium, they dropped from the analysis. The repeated measures design showed that neither the main effects nor their interactions were significant. These results indicate that there were no significant changes in errors across the Easy Task nor did A-State effect responding in this section.

Discussion

It was found, as hypothesized, that subjects' responded to difficult CAI materials with a greater increase in self-report and physiological measures of A-State than was the case for Easy CAI materials. Both STAI A-State scores and SBP scores increased during a Difficult CAI task and decreased during the Easy CAI task. There were no Sex effects for the STAI A-State measures but the SBP scores for males were significantly greater than females. The most parsimonious explanation of this latter difference is that SBP is dependent upon physical characteristics such as height, weight and body build. Therefore, since males are taller and heavier than females, it was expected that males would respond with higher levels of SBP than females.

The analysis of mean errors across Task Periods indicated that the Tasks were appropriately labeled Difficult and Easy. The mean number of errors per item in the Difficult Task Period was 2.17, while the errors drop to almost zero in the Easy Task Period. Since there were so few errors in the Easy Task Period, the analysis of the relationship between A-State and errors focused on the Difficult-Task Period. There were actually two levels of difficulty for this Difficult-Task Period, corresponding to Diff/(1-5) and Diff/(6-17). The mean number of errors for Diff/(1-5) was 2.76 and for Diff/(6-17) was 1.58. This decrease in errors would indicate that subjects were learning the material.

For Diff/(1-5), Hi A-State subjects made more errors than subjects who were low in A-State; however, Lo A-State subjects made more errors than Hi A-State subjects on Diff/(6-17). There was also a significant main effect of Tasks-Period in the Difficult Task Period indicating that Diff/(1-5) and Diff/(6-17) were significantly different.

The relationship of A-State and errors is complex. For those aspects of the CAI tasks in which errors were high, Hi A-State subjects did not do as well as Lo A-State subjects. In those sections of the CAI tasks in which errors were relatively few, Hi A-State subjects did as well or better than Lo A-State subjects.

The relationship between anxiety and learning depended upon whether A-State was aroused in the situation and the relative strength of competing response tendencies. These results are consistent with Spielberger's (1966) extention of the Spence-Taylor Drive Theory. In this State-Trait theory, an index of transitory drive (A-State) is available. It is this transitory drive that is related to levels of task difficulty and resulting errors.

FIGURE 1

DIFFICULT MATERIALS FORMAT

Step 1: We will show that for all pairs of elements in C, that their sum is also an element of C. To do this, we will select two arbitrary elements Z1 = (a,b) and Z2 = (c,d) and show that Z1 + Z2 is an element of C.

Step 2: Z1 + Z2 = (a,b) + (c,d) (Type the abbreviation to justify this step.)

Step 3: Answer: Substitution (The subject types "S".)

Step 4: Make sure that you are using the abbreviation on page 10. If R = 8 and S = 7, then 8 + 7 may be written in place of R + S. Try again.

FIGURE 2

EASY MATERIALS FORMAT

Step 1: There are two ways that this computer can write the fractional number three-fourths. One way is $\frac{3}{4}$ .. The other way is 3/4. In this program, all fractional numbers will be written like this - 3/4. You are going to need a little practice.

Step 2: Type two thirds.

Step 3: (Answer) 2/3

Step 4: You should have typed 2/3. Try again.

Figure 3

MEAN A-STATE SCORES ACROSS TASKS-PERIODS

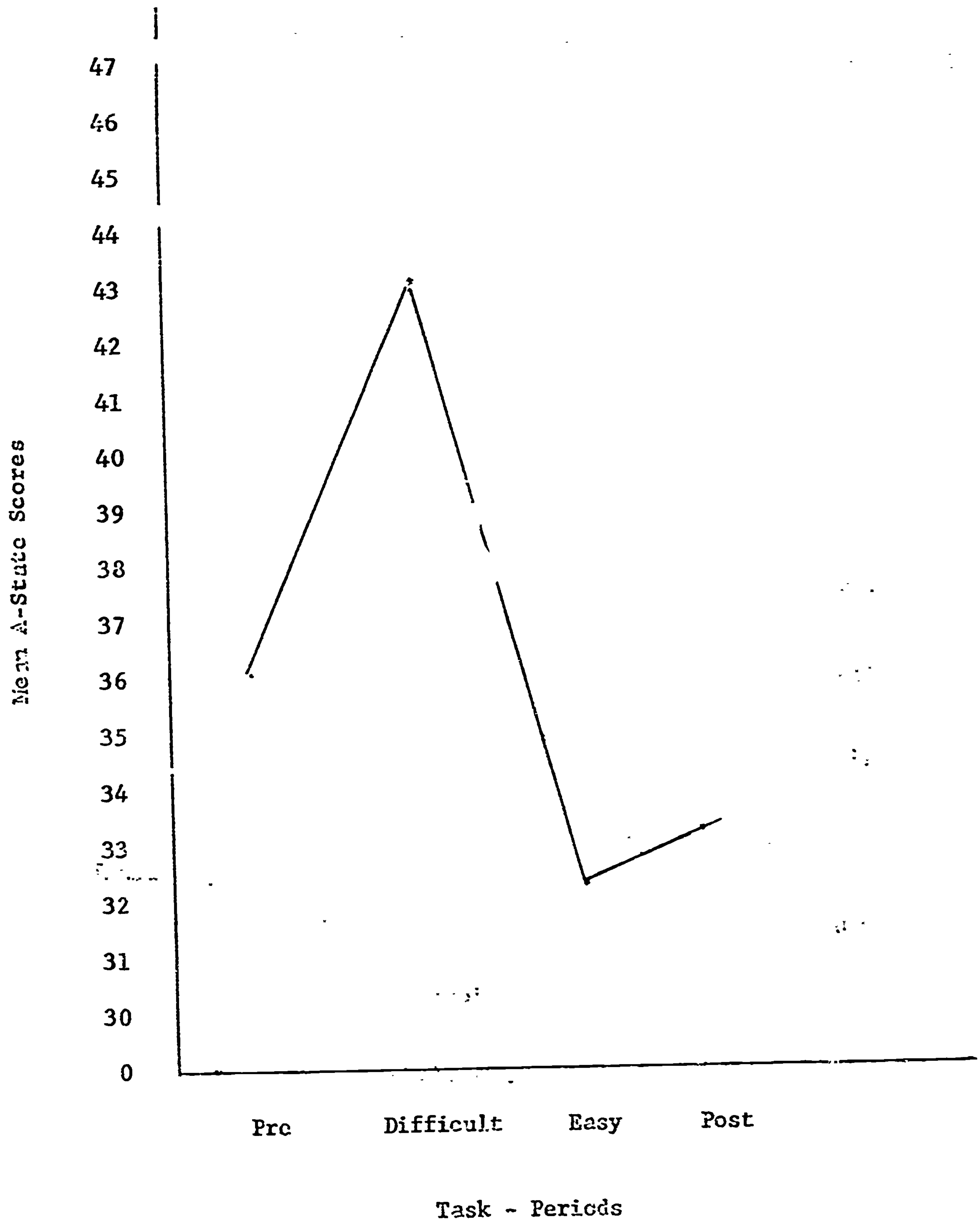


Figure 4

MEAN SYSTOLIC BLOOD PRESSURE SCORES ACROSS TASKS-PERIODS

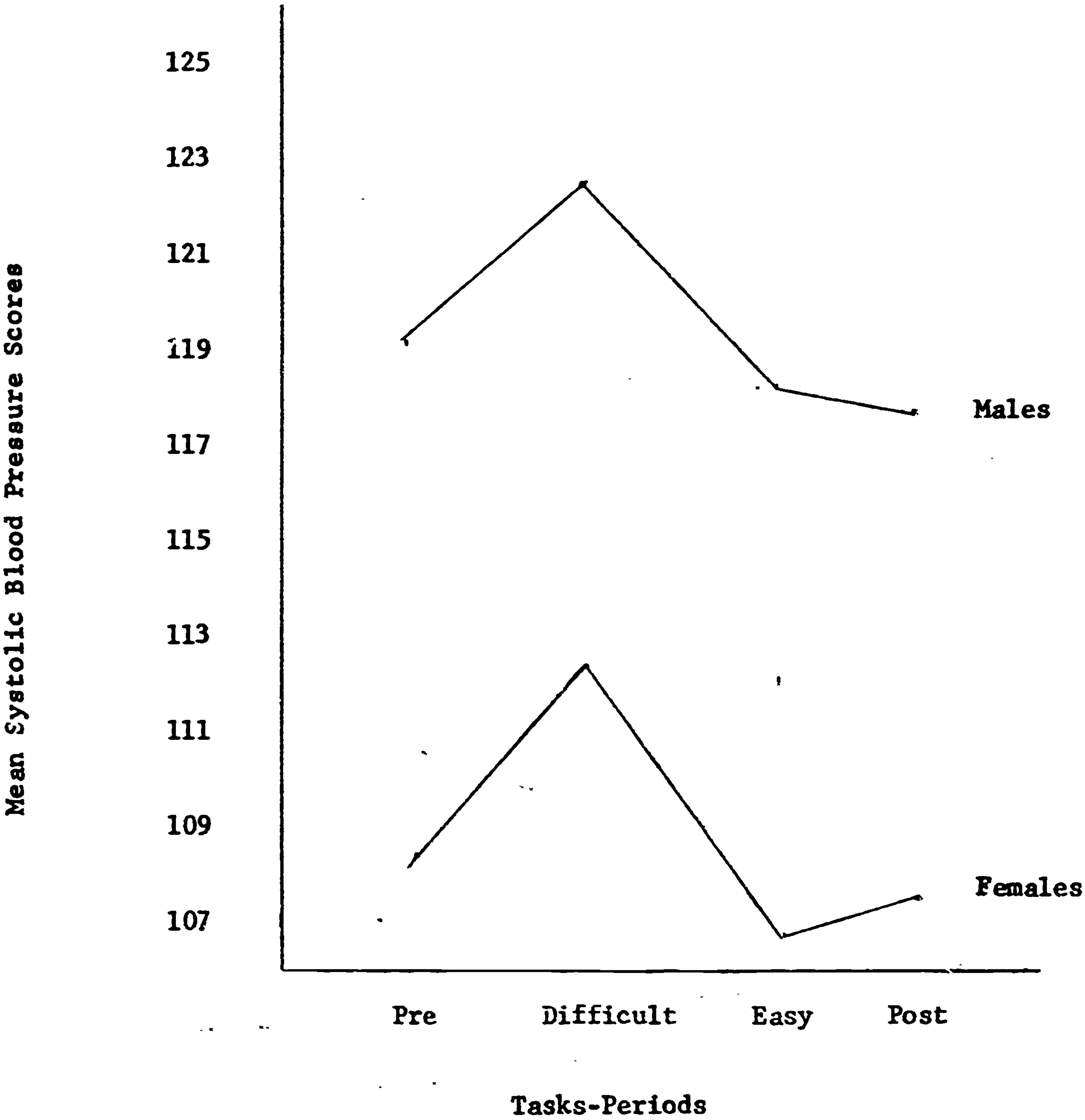


Figure 5

MEAN ERRORS PER RESPONSE

ACROSS TASK PERIODS

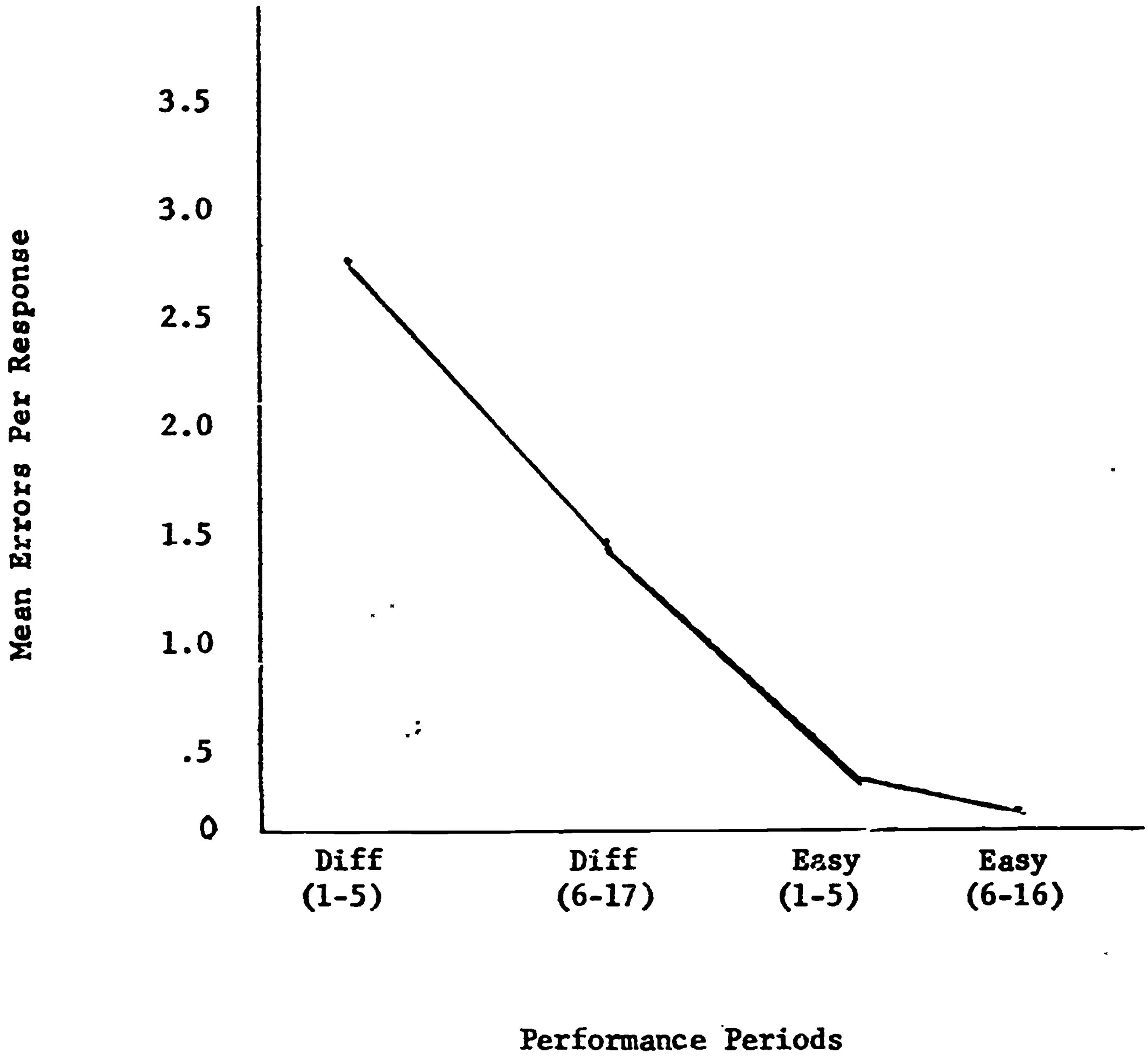
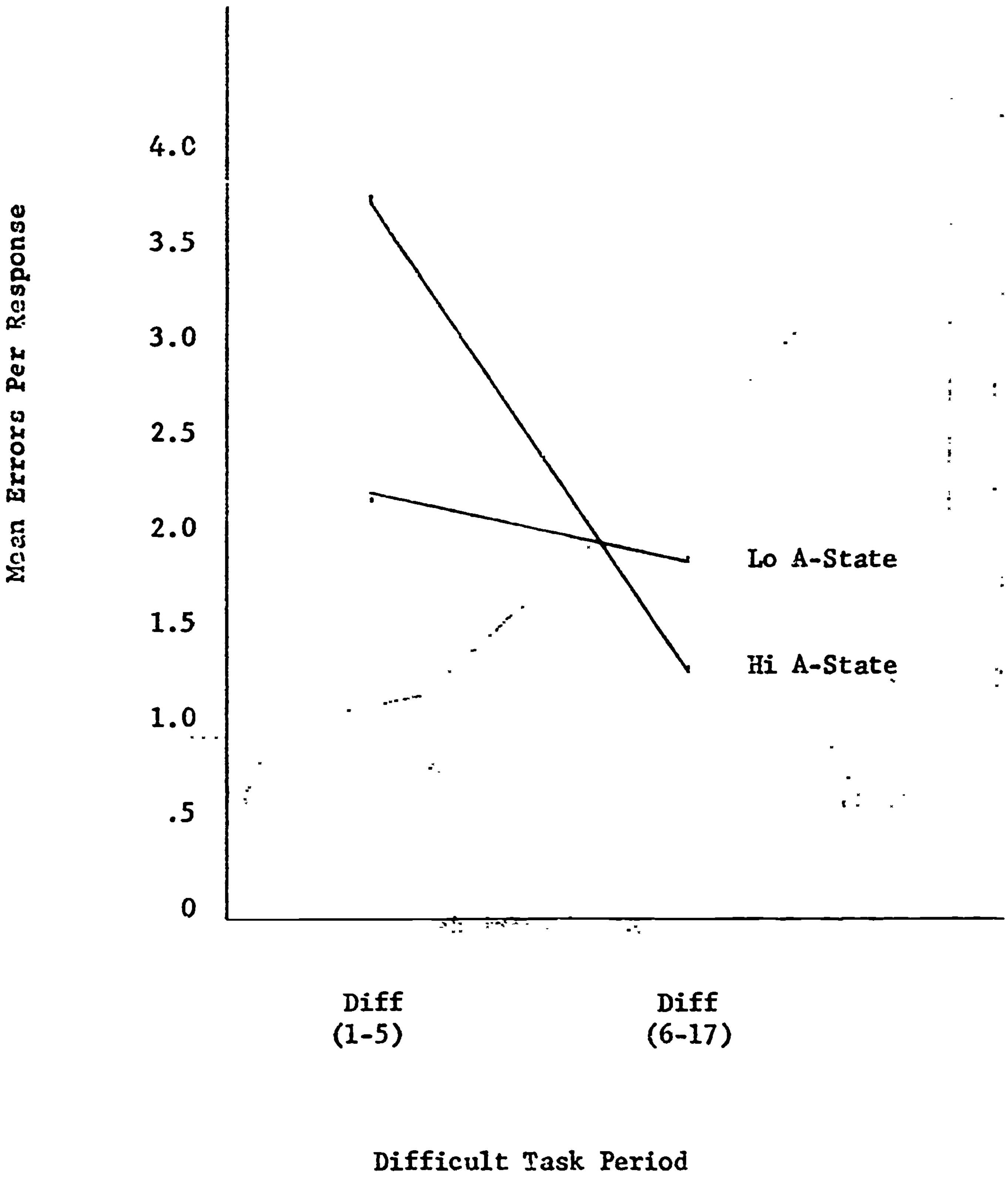


Figure 6

MEAN ERRORS PER RESPONSE FOR HI A-STATE AND

LO A-STATE Ss IN THE DIFFICULT TASK PERIOD



Comparison of feedback by verbal definition and feedback by example on two consecutive steps from one of the proofs, showing typical student responses for instances where at least two errors were made.

	Group I - Verbal definition	Group II - Numerical example
Computer	(a,b) + (c+e,d+f) = (a+(c+e),b+(d+f))	(a,b) + (c+e,d+f) = (a+(c+e),b+(d+f))
S	ca	am
Computer	No. We combined two complex numbers into one complex number. What rule allows this?	No. Why does (6,8) + (3,4) = (9,12) ? Try again.
S	dc	aa
Computer	No. We combined two complex numbers into one complex number. What rule allows this?	No. Why does (6,8) + (3,4) = (9,12) ? Try again.
S	dm	tr
Computer	No. We combined two complex numbers into one complex number. What rule allows this?	No. Why does (6,8) + (3,4) = (9,12) ? Try again.
S	da	da
Computer	Correct	Correct
Computer	(a+(c+e),b+(d+f)) = ((a+c)+e,(b+d)+f)	(a+(c+e),b+(d+f)) = ((a+c)+e,(b+d)+f)
S	da	dc
Computer	No. Numbers are added two at a time. This rule tells us that it makes no difference which two are added first. Try again.	12+(13+14) = (12+13)+14 is an example of what happened. Try again.
S	ca	ca
Computer	No. Numbers are added two at a time. This rule tells us that it makes no difference which two are added first. Try again.	12+(13+14) = (12+13)+14 is an example of what happened. Try again.
S	aa	aa
Computer	Correct.	Correct.

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THE ROLE OF CAI IN THE FORMATIVE EVALUATION OF THE INTERMEDIATE SCIENCE CURRICULUM STUDY*

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The Intermediate Science Curriculum Study of Florida State University, under the direction of Professor Ernest Burkman, was granted a five-year contract in May, 1966, by the U.S. Office of Education to develop a sequential science curriculum for the seventh, eighth, and ninth grade levels, and to conduct research based on this curriculum. This research is designed to yield information about instruction and learning that will, in turn, be applicable to other subjects and grade levels.

The strategy for instruction being employed by ISCS is a unique one. It takes into account what teachers, administrators, and perceptive parents have long recognized--the fact that youngsters vary tremendously both in their capacity to learn and in the rate at which they are able to learn.

ISCS is working to build a practical program of more individualized science instruction. Our concept of the teaching-learning situation is one in

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which much of the student's work is conducted independently, with the teacher moving from individual to individual, giving clues, asking questions, correcting misconceptions, and extending concepts to new situations. In this approach, the learning pace is set by the student, and the level of instruction is automatically adjusted to his ability.

To allow for individual differences in ability, two types of student materials are being developed. The primary sequence for each grade provides the basic "story line" that every student follows. "Excursions" are separately bound materials that provide departures from the primary sequence. There are two kinds of excursions. Enrichment excursions are designed to provide greater challenge for the more able student, or for the student interested in pursuing a topic in greater depth. Remedial excursions provide the slower student, or less well-prepared student, with special background or skills needed for efficient progress in the main-line sequence. Through selection and judicious use of excursions, the ISCS teacher may design a multi-track program specifically geared to his own students.

Both the core sequence and the excursions are written in a semi-programmed style which permits students to proceed independently and at their own pace. (Figures 1 and 2 illustrate the text format. They are reproduced from the seventh grade text materials.) Note that the text serves as lab guide and record book, as well as a source of conceptual and factual information.

Insert Figures 1 and 2 about here

Evaluation and Field Testing

Instructional research workers have long wished that they could somehow peer into the brain of each individual as he passes through a sequence of instruction. If this were possible, one could pinpoint the exact areas of the sequence that cause difficulty for specific types of individuals. Information of this sort could obviously make the task of building and revising instructional materials easier and much more efficient.

Not being able to probe directly into a student's mind, ISCS is gathering a record of student responses in a less direct fashion--by using computer-assisted instructional techniques. As the student text materials are produced and sent out to be tested by over 12,000 students and 100 teachers, they are also programmed for entry into an IBM 1500 computer at the Florida State University Computer-Assisted Instruction Center. Sixteen seventh graders of different abilities are presently serving as trial students for ISCS using CAI. Every response made by every child to each step of the sequence is stored by the computer on magnetic tape. This information is being used to help determine which portions of the classroom sequence should be revised, eliminated, or converted into "excursions."

This use of computer-assisted instruction (CAI) in the formative evaluation of the ISCS seventh grade materials complements the concurrent large-scale classroom trial. The CAI evaluation permits greater control of a multitude of variables that are common to the science classroom, and that inevitably bring large-scale classroom evaluation into question. Such variables as teacher behavior and training, different classroom environments, over-crowding, lack of facilities, etc., are minimized with the CAI presentation. The CAI evaluation can thereby focus on providing objective data related to conceptual, sequential, and mechanical problems inherent in the curricular materials. And, since complete records of each individual are obtained, a precise measure of how a student's ability relates to his daily progress is readily available.

The CAI Materials

Because the ISCS seventh grade textual materials have a semi-programmed, self-pacing style, and because these materials contain many questions for the student to answer, they have proven to be readily adaptable to CAI presentation. This adaptability of text to computer programming is critical in producing the desired match of CAI program and classroom materials. If the evaluation of the course via CAI is to be meaningful, we feel that it is essential that students see and work with the same materials, organized in the same order as those of the text, and have the same laboratory experiences as students taking the course in the ordinary ISCS classroom.

For the most part, the CAI program is written in linear form; that is, the student proceeds along a single path. This matches the main-line sequence of the text. However, branching is employed extensively in the sequence to include the all important remedial and enrichment excursions. Entry to all remedial excursions is based on check-up frames such as the one shown in Figure 2. The student, in consultation with an adult proctor, decides whether or not to take an enrichment branch. Each excursion is programmed to provide an automatic reentry to the main line at the original point of departure.

The formative evaluation of ISCS materials, using CAI, was begun in the fall of 1966. This corresponded to the first year of the classroom trial of the textual materials. The presentation of the ISCS program by computer has been made possible through the cooperative assistance of the staff of the Florida State University CAI Center. This first year of CAI evaluation was an important learning period in regard to how one best obtains and processes feedback. Much of what we learned from this first year's experience is now having an important effect on our approach to the second year of CAI evaluation.

Before describing what we have learned about the specifics of our approach to CAI evaluation of the ISCS materials, let me emphasize once again the intent of ISCS in approaching formative evaluation of curriculum in this way.

First, we are intensely interested in what happens to individuals as they proceed through the course. We think CAI provides the surest and cleanest way of examining individual differences in the context of a science course. Using CAI to look at individual records provides the kind of evaluation which cannot be readily obtained in the large-scale classroom approach.

Secondly, we are attempting to provide data about how course sequence and construction relate to student progress. Therefore, if these data collected via CAI are to be meaningful in the formative evaluation of classroom text and lab materials, we are committed to presenting, by CAI, a program that matches the current text. Our immediate goal is not to produce the best possible computer program for science instruction, but rather to produce a sound three-year course for classroom presentation. Eventually, we plan to turn more attention to the development of multi-track CAI programs for the ISCS materials, but our immediate concern is with text revision.

Now, let me describe some of the changes in approach that have resulted from our 1966-67 experience. Hopefully, this will give you a fairly clear picture of our present operation. I shall limit this discussion to the more important problems we have faced, and the decision they have prompted us to make.

First, we have decided that an even closer match of computer program and classroom text is suitable. During the first trial year, we sought to get the most precise analysis of each text section by fragmenting large paragraphs into specific questions. In other words, we were frequently converting declarative statements into interrogative ones. For example, suppose the classroom text was as follows:

"The blade of the force-measurer is bent by the weight hanging on it."

The computer program would have presented this statement as a question:

"What caused the blade of the force-measurer to be bent?"

A set of multiple-choice responses would then be presented, or the student would be asked to type a free response answer.

In order to make sure the student knew the initial piece of information given in the declarative statement, he would be told by the computer whether or not his answer was correct; or he would be told what the correct answer should be. In this way, each correct student response would be reinforced. This programming technique seemed most appropriate, in that it followed Skinnerian philosophy of programmed instruction. But, this method of programming proved to be the basis of much criticism. It was argued, and justifiably so, that we could not be sure what effect knowledge of results and reinforcement were having on student learning. Therefore, we could not attribute progress to text design only.

Our approach this year is to preserve the exact wording of the text and to provide knowledge of results and reinforcement only when they are found in the corresponding textbook sections. For example, look at the following text passage. It is reproduced word for word in the computer program. You will note that knowledge of results is included in the text passage.

2-18. Whose battery do you think did the most work? ____________

One thing is pretty obvious by now--comparing work is not easy. Discuss the problem with others in your group and with the class if your teacher calls you together. Try to come to some agreement as to whose battery did the most work.

No matter how you tried, you could not get a complete answer to the question. Part of your trouble can be blamed on the fact that the meaning of work has not been clearly stated. We have been using the word very loosely.

You did, however, learn that the following might be important:

1) How many sinkers were lifted.
2) How far the sinkers were lifted.
3) How fast the sinkers were lifted.

We have also decided that programming and testing first version materials with an eye to text revision is not an efficient use of manpower and machine time. The beauty of CAI for evaluation lies in its complete and precise record-keeping. First version text materials--at least our first version materials--do not warrant such a precise evaluation. Most of the changes that need to be made are gross, and therefore quite obvious to a person trained in science or science education. CAI evaluation certainly identifies these problem spots, but unless there is an abundant supply of manpower, and unless computer time is inexpensive, data needed for first revision can be obtained more efficiently through regular classroom trial. For these reasons, we are presently evaluating only second version materials of the seventh grade. Our original plan to run a simultaneous CAI evaluation of the eighth grade materials is being delayed until a year of classroom testing and subsequent first revision are complete.

Much to our chagrin, during the first year's evaluation, we discovered that computers with CAI capability generally do not come with ready-made data analysis programs. Moreover, the variety of computer languages and systems being used by CAI groups around the country varies so much that efforts to interchange analysis programs have been almost fruitless. The 1500 system has the hardware capability for data analysis, but no well-developed software system for implementing the analysis. The CAI Center staff at FSU is rapidly developing a set of programs that serves the general needs of the many groups utilizing their equipment. Concurrently, the ISCS staff is developing programs that will meet our more specific analysis demands. These programs take advantage of an intricate and broad system of frame classification which we began using this year.

In the first year's program, coding of frames was limited to identification according to chronological sequence within the program. We found that this limited classification did not facilitate the investigation of the relationships between different science content and process themes. A more extensive coding was essential if precise judgments were to be made regarding particular characteristics of the materials.

The development of a ten-character, alpha-numeric code now makes it possible to identify each program segment and question according to its position in the text sequence, according to the specific science content and process with which it deals, and according to its remedial enrichment or diagnostic characteristics. It is now becoming possible to retrieve these data in many different ways, depending upon particular evaluative interests.

For example, we may be interested in knowing if the difficulty of the concept of kinetic energy appears to be related to the difficulty with the concept of speed. We can use the coding scheme to single out all parts of the text related to these two concepts, and investigate the student error rate (individual and/or group) for these items. This potential data bank and retrieval system make possible any number of specific investigations that are useful, not only in the revision of materials, but in investigating which particular content sequence is most logical to different kinds of students. Computer programs are now being written to make possible the full utilization of the available data.

Because of the many demands and problems of a first year's effort, we found it impossible to make the most efficient use of the CAI evaluation in textual revision. The data analysis provided the revision team was fairly complete, but the method of presenting it proved to be somewhat inappropriate. We made two assumptions which we later decided were in error.

First, we assumed that the writers would have more time than they actually did at the beginning of the revision conference to examine the data in some detail before beginning rewrites. Secondly, we assumed that we should provide the writers with an unbiased presentation of the data, rather than our own interpretation of what the analysis suggested about the materials. In this way, they would be free to make their own judgments.

We chose to present the various kinds of data collected on a chapter-by-chapter basis, and to make these summaries available to each member of the revision team. Let me describe these summaries briefly. Even though the method of presenting the analysis is being revised, these data do exemplify the kinds of things we feel are useful in approaching revision.

Each chapter report included individual and group records of every student response, i.e., a complete listing (including every question) of all correct (ca), incorrect (wa), and all unanticipated (un) responses. These data were summarized by the computer and tabulated so that questions frequently answered incorrectly could be easily identified. An example of a portion of such a listing is shown in Table 1.

TABLE 1

Question Number	Student Number Decreasing Ability Level →							
	8	7	6	5	4	3	2	1
14.5	ca	ca	ca	ca	ca	ca	ca	ca
14.6	ca	wa	ca	un	ca	ca	ca	un
14.7	un	un	un	un	un	un	un	un
14.8	ca	un	ca	un	ca	ca	ca	un
14.9	wa	wa	ca	ca	wa	ca	un	un

(Note that these data can be used to study individual or group progress through the chapter material. From the responses shown here, it is evident that student #3 had more correct responses than students #7 and #8, despite his lower ability level.)

Letter designations have the following meanings: ca - correct response; wa - incorrect response; un - unanticipated response.

The record shown in the table includes first pass responses only. That is, the responses are those which occur the first time each of the students approaches a specific frame.

The chapter summaries also contained a time chart (not shown) which allowed for an easy comparison of the students with respect to their rates of progress through the textual sections and laboratory activities. This year, we will have latency data for every program frame.

Also included in the chapter summaries were data on the percentage of correct answers for each student for each chapter. An example is shown in Table 2. These data provided a rough measure of the difficulty of the chapter for each student, and for the total student group.

TABLE 2

	Student's Percent Correct Scores (Students Ranked By Decreasing I.Q.)							
	8	7	6	5	4	3	2	1
Chapter 6	88.9	81.5	86.4	77.8	65.4	77.8	66.7	61.7
Chapter 7	85.3	76.0	84.0	82.7	70.7	68.0	60.0	58.7
Chapter 8	85.7	79.6	75.5	75.5	71.4	71.4	67.3	59.2

Student performance in the CAI program was also correlated chapter by chapter, with their ability levels and with their achievement on ISCS subject-matter content tests. Table 3 gives a sample of this data.

TABLE 3

Group Product Moment Correlations

	Chapter 6	Chapter 7	Chapter 8
% Correct vs. Aptitude	.85	.87	.97
% Correct vs. Achievement Test	.77	.88	.75

The summaries also included a page-by-page comparison of the CAI information with the ISCS text. These comparisons were designed to give the revision team an efficient means of determining which text sections were related to specific CAI questions. With our new coding scheme, we can identify every program frame according to its exact correspondent in the classroom text.

Finally, the chapter summaries contained proctor notes on student discussions and otherwise unrecorded incidents related to problem areas in the computer program, in the ISCS text, and in the laboratory materials. These notes also contained the proctor's reactions to specific problems, his methods of assisting students in the solution of these problems, and his subjective impressions of the student's progress, attitudes, and understanding. In addition, all experimental data collected by the students and all student-written responses which had been entered in a mimeographed student text were presented in condensed form.

Even though many changes in the classroom text resulting from the revision can be traced to the outcome of the CAI evaluation, the need for gross changes in the materials, as mentioned earlier, overshadowed these more specific alterations. Time did not allow all the writers to fully digest the CAI data. There simply was too much to examine. As a result, we have decided to change the format of analysis presentation. It appears to us that efficient use of the kind of CAI data we have requires a greater condensing of the records and a fairly specific interpretation of the data analysis. In other words, we feel that the CAI data will be utilized much more effectively if the writer can quickly see its relationship to trouble spots in the textual materials and what this relationship suggests about needed changes.

Prior to the 1968 summer revision conference, we intend to produce written summaries of our interpretations of what the analysis means with respect to specific revision needs. For example, we plan for our summaries to provide the kind of information illustrated in the following paragraph:

> We find that the concept of kinetic energy is not being applied correctly by the student in Chapter 9 as indicated by the high error rate on Questions 9-34, 9-37, and 9-41. This appears to be related to the difficulty with the concept of speed in Chapter 6, Questions 6-12, 6-15, 6-16, etc. It may be possible to correct this by rewriting the first activity in Chapter 6, with special attention being given to the relationship of time and distance of the moving cart. It may also be necessary to write another remedial excursion dealing with division of decimals.

If concrete suggestions of this sort are provided, we feel that the writers can be helped greatly in their revision task.

Let me quickly summarize what I have said, and project a bit into the future for ISCS. I have emphasized in this report our efforts to employ computer-assisted instruction in the formative evaluation of the ISCS science course. Matching computer program to the textbook provides the key to revision of the classroom materials. Revision of these materials in turn leads to revision of the computer program. The alternating stepwise improvement of text and computer instruction should eventually produce both a carefully revised classroom text and a refined CAI program. We envision such a computer program as possessing intricate branches designed to provide for the needs of different kinds of students. This is one of the ultimate outcomes of the current CAI formative evaluation. As has been emphasized, however, our immediate concern is with text revision.

We hope that, by the time the ISCS project is completed in August, 1971, we will be able to state with a good deal of confidence what students, who take either the CAI or regular ISCS seventh through ninth grade self-paced program, can be expected to be able to do at any given point in the sequence.

The size and comprehensiveness of the ISCS sample, the nature of the materials being developed, and the large bank of easily retrievable data being collected offer unique possibilities for much needed longitudinal research. As mentioned earlier in this paper, research is to be a vital part of the project effort. Hopefully, such research will provide knowledge about learning and instructional sequencing that will be applicable to other subject fields and other levels of instruction. Some studies have already been begun but, up to this point, much of the time of the project staff and graduate students has been invested in developing materials and in organizing the information-collecting and retrieval system. As the need for this phase of the effort lessens, we plan to devote progressively more time to more systematic research.

REFERENCES

Burkman, Ernest. The Intermediate Science Curriculum Study (ISCS) Program of Individualized Science Instruction For Grades Seven Through Nine. A report given at The Forum on Individualization In Science Instruction, sponsored by Research For Better Schools, Inc., Philadelphia, Pa., December, 1967.

ISCS Project Brochure. Second edition. Tallahassee, Fla.: Florida State University, December, 1967.

Snyder, W. R., Flood, Paul K., and Stuart, Michael. Use of CAI in Evaluation of the ISCS Seventh-Grade Course. ISCS Newsletter, June, 1967.

page 7-2

Comparing jobs that are similar is fairly easy. Carry this a step farther by making the jobs even more alike. Suppose you wanted to lift a ten-kilogram block to the top of a wall one meter high. Figure 7-1 shows three ways of doing the same job.

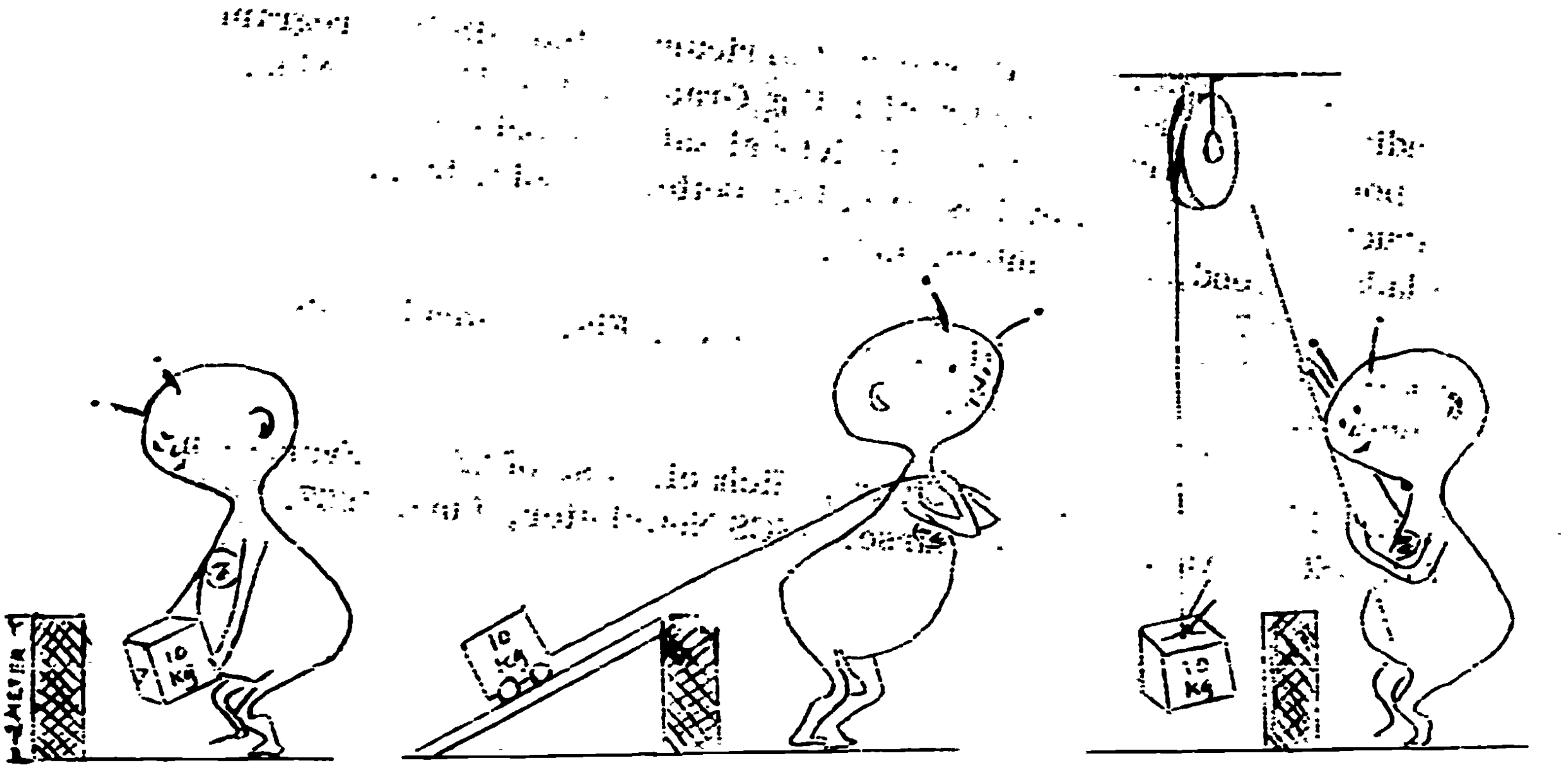

Figure 7-1

7-3. When the boys shown in Figure 7-1 had finished their jobs, which boy (A, B, or C) had accomplished the most?

____

7-4. Which job was the hardest to do? __________________

7-5. Which boy did the most work? __________________

Look again at the illustration, and you will see that each boy did exactly the same job. Each lifted the block to the top of the wall. You may think that one way of doing the job was easier than the others, but the work done was the same in all three cases.

As part of the activities for this chapter, you will actually lift an object as shown in Figure 7-1. That is, you will do the same amount of work in several ways. You will measure the variables involved and try to find one that remains the same no matter how the work is done. This will give you a measure of work.

FIGURE 1

page 2-6

By this time you may have gotten numbers like 1.2 meters or $3\frac{1}{2}$ seconds. Such numbers (containing decimals or fractions) are called mixed numbers. As you might guess, you will be using mixed numbers, particularly decimals, from now on. Do Checkup Frame 2-2 before going any further in this book.

Checkup Frame 2-2

Solve the following:

1) 3.7 x 2.5 =

2) 0.9 x 4.6 =

3) 8.46 ÷ 0.2 =

Check your answers on page 1 of Excursion 1-1.

Perhaps the work of lifting sinkers is different from the work of dragging them. To find out, make the battery and motor drag the sinkers across the table as shown in Figure 2-1. Once more you should be working with five of your classmates, possibly the same ones. Record the information from these trials in Table 2-3.

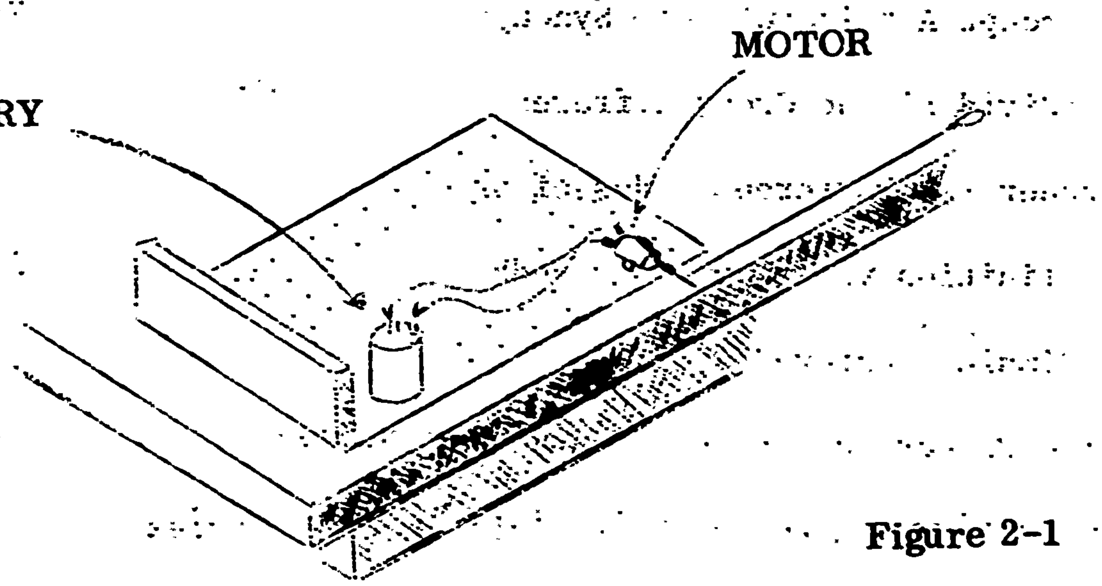

Figure 2-1

Name of Group Member	No. of Sinkers Dragged	No. of Times Dragged	Distance from Hook to Pulley (in centimeters)	Total Distance Dragged	Total Time for Dragging (in sec)
	1	6			
	2	5			
	3	4			
	4	3			
	5	2			
	6	1			

Table 2-3

FIGURE 2

APPENDIX A

JULY 1, 1967 through December 31, 1967

1440 System

Project Number	Project Title	Phase	Project Info. Form
0006	Concepts in Social Work	V	**
0015	Physics Problems for Homework and Review	V	**
0016	Junior High Curriculum Project	Note 5	**
0017	Conditioning of Word Meaning	Note 4	**
0018	Concept Attainment thru Synonyms	Note 4	**
0019	Individual and Group Differences in Learning under Two Different Modes of CAI	Note 3	**
0020	Definition vs Example as Feedback in a CAI Stimulus Centered Program	Note 3	**
0021	The Effects of Idiosyncratic Reinforcement Conditions on Learning Acquisition of a Complex Numbers Program	Note 3	**
1040	CAI Applied to Basic Computer Programming of IBM, 1440 System in Autocoder	V	**
1041	CAI Applied to Basic Computer Programming of IBM, 1440 System in Fortran	V	**
1047	General Chemistry Solving	IV	**
1048	CAI in the Arts for Elementary Education	IV	**

1049	An Experimental Study of the Effects of Linking	Note 6	**
1050	Anxiety and Basic Difficulty using CAI Media, I	V	*
1051	Effects of Three Instructional Strategies on Achievement in a Remedial Arithmetic Program	Note 3	*
5001	CAI time Usage Program Summary by Course	Note 2	**
5002	CAI time Usage Program Summary by Date	Note 2	**

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* Included in Appendix B of this report

** Included in Appendix B of previous report

Note 1--This is an ongoing project of the center and will have no phase designation.

Note 2--This is an IBM project and has no phase designation.

Note 3--This project is completed and the summary report is included in this report.

Note 4--This project has been terminated.

Note 5--This project has been transferred to the IBM 1500 CAI System.

Note 6--Summary report is included in the Semi-Annual Report, January 1,1967

APPENDIX A

PROJECT STATUS REPORT

July 1, 1967 through December 31, 1967

1500 System

Project No.	Title	Phase	Project Information form
0001	Anxiety and Task Difficulty using CAI Media, II	V	*
0002	CAI Project in Introductory Physics	V	*
0003	CAI Evaluation of ISCS Text and Lab Materials	IV	*
0004	Interaction of Examiner Attitude with Praise and Blame	III	*
0005	Attitudes to Teaching Methods	I	*
0006	An Experimental Thesis Study in Public Address, Speech Department	I	*
0007	Kuder	III	*

COMPUTER ASSISTED INSTRUCTION CENTER

FLORIDA STATE UNIVERSITY

PROJECT INFORMATION FORM

1440 SYSTEM

Date July 1, 1967 Project Number 1050

Project Director: Harold F. O'Neil, Jr.
Other project personnel: Dr. Duncan N. Hansen, Advisor
Dr. Charles Spielberger, Advisor

Project Title: Anxiety and Basic Difficulty using CAI Media.

General Nature of Project: Investigate effect of anxiety upon the learning process.

Objectives:

1. Manipulate level of difficulty within a program.
2. Differentially increase state anxiety in Ss differing in trait anxiety.
3. Demonstrate that this differential increase should interact with IQ to produce differential performance on the same task.
4. Produce changes in blood pressure depending upon difficulty level of program.

Population: Male introductory psychology students.

Procedures:
General Design: See appendix

Analysis:

1. Pre-post anxiety comparisons
2. Pre-post blood pressure comparisons
3. Error rate of HL and LO A Ss
4. Time to complete program
5. Anxiety levels (state) during the program
6. Blood pressure changes during the program

Data to be collected and method of collection:

Expected Results: See "Remarks" below

Titles of CAI courses used in Project: Psystudy
1. Complex
2. Compfrac

Auxiliary or Special materials to be used:

1. State-trait Anxiety Inventory
2. Booklet containing instructions

Remarks:

Anxiety Scales

1. HLA on the difficult part should show highest score on state anxiety measures.
2. LOA on the difficult part should increase scores from pretest levels but be less than HLA.
3. LOA & HLA on the easy part should both decrease in state anxiety.

Performance on the program

1. It is expected that our trials, that HLA's will do poorer than LOA's.
2. The exact nature of the anxiety - IQ interaction will be determined by the amount of anxiety engendered and the difficulty level of the program.

Blood pressure

1. During the difficult sentence blood pressure should increase from pre-program level.
2. It should decrease during the easier section from difficult section level.
3. After a 5 minute wait following the program, it should return to baseline.

COMPUTER-ASSISTED INSTRUCTION CENTER

FLORIDA STATE UNIVERSITY

PROJECT INFORMATION FORM

1440 SYSTEM

Date September 26, 1967 Project Number 1051

Project Director: Dr. Howard Stoker
Other project personnel: Neil Shaw, Programmer

Project Title: Effects of Three Instructional strategies on Achievement in a Remedial Arithmetic Program.

General Nature of Project: Dissertation

Objectives:

Population: Junior High School (low achievers in arithmetic) Leon County Schools, 60 student subjects on CAI.

Procedures:
General Design: Four groups, three experimental and one control

Analysis: t tests of differentials between means and proportions.

Data to be collected and method of collection: Pretests, two posttests (paper and pencil), performance on program segments (student records).

Expected Results:

Titles of CAI courses used in Project: addsub

Auxiliary or Special materials to be used: None

Calendar:
Project Starting Date: October 3 Expected Completion Date: October 27

Date of First Machine Usage: September, 1967

Type of Use: Entry and debug.

Anticiapted Total Time per Student: Three hours

Number and Length of Student Sessions: Two-four, approximately one hour each.

Remarks:

COMPUTER-ASSISTED INSTRUCTION CENTER

FLORIDA STATE UNIVERSITY

PROJECT INFORMATION FORM

1500 SYSTEM

Date September 21, 1967 Project Number 0001

Project Director: Harold F. O'Neil, Jr.
Other project personnel: Dr. Duncan Hansen, Dr. Charles D. Spielberger, Advisors

Project Title: Anxiety and Task Difficulty Using CAI Media, II.

General Nature of Project: Investigate the effect of anxiety upon the learning process.

Objectives: Provide replication of Paystudy; collect latency data on responding.

Population:
Sample: Introductory Psychology students

Procedures:
General Design: See Appendix.

Analysis:
(1) Pre - post anxiety comparisons
(2) Pre - post blood pressure comparisons
(3) Error rates of Hi and LoA Ss
(4) Latency data - descriptive statistics
(5) Anxiety levels (state) during the program
(6) Blood pressure changes during the program.

Expected Results: See below (Remarks)

Titles of CAI courses used in Project: Psy 2

Auxiliary or Special materials to be used:
State - Trait Anxiety Inventory
Booklet containing instructions

Remarks:

Anxiety Scales

1. HLA on the difficult part should show highest score on state anxiety measures.

2. LOA on the difficult part should increase scores from pretest levels but be less than HLA.

3. LOA and HLA on the easy part should both decrease in state anxiety.

Errors

1. On the very difficult section HLA should have more errors than low A's given equivalent ability.

2. On the easy section HI should have fewer errors than LOA.

Blood Pressure

1. During the difficult section, blood pressure should increase

2. It should decrease during the easy section.

Latencies

1. Empirically collected and analyzed.

COMPUTER-ASSISTED INSTRUCTION CENTER

FLORIDA STATE UNIVERSITY

PROJECT INFORMATION FORM

Date September 1, 1967 Project Number 0002

Project Director: Dr. Duncan Hansen
Other Project Personnel: Mrs. Ora Kromhout, Miss Marjorie Nadler, Mr. Bob Hogan--writers. Drs. Steve Edwards, Neil Fletcher, J. W. Nelson, G. Schwarz.

Project Title: CAI Project in Introductory Physics (Physics 107)

General Nature of Project: Development of materials for a completely autonomous course, and testing on a group of students. ("Autonomous" here means that the student does not attend any conventional lecture presentations; total instructional experience takes place at the CAI Center.)

Objectives: One-quarter course, presented twice - Fall quarter, 1967; Spring quarter, 1968. Winter quarter to be used for evaluation and improvement. Objectives are to investigate the applicability, merits, and costs of such a course.

Population: College students, mostly freshmen, primarily not science majors, with little mathematics training.
Sample: 23 volunteers from the roster of (more than 700) registered Physics 107 students.

Procedures:
General Design: IBM 1500 computer used; CRT terminals; language - COURSEWRITER II.

Analysis:

Data to be collected and method of collection:

Expected Results:

Titles of CAI courses used in Project: P107, physics 1, physics 2

Auxiliary or Special materials to be used: (1) 16mm P.S.S.C. movies (P.S.S.C. means Physical Science Study Committee)
(2) super-8mm concept films
(3) tape-recorded lectures
(4) booklet of mimeographed supplementary sheets
(5) homework assignments and textbook used by students in the "conventional" sections of the class

Calendar:

Project Starting Date:

Date of First machine Usage:

Anticipated Total Time per Student: about 30 hours

Number and Length of Student Sessions: about 29 sessions, about one hour each

Dates:

Remarks:

COMPUTER-ASSISTED INSTRUCTION CENTER

FLORIDA STATE UNIVERSITY

PROJECT INFORMATION FORM

1500 System

Date September, 1967 Project Number 0003

Project Director: Dr. Ernest Burkman
Other project personnel: Dr. William Snyder, Coordinator, CAI-ISCS
Mr. David Dasenbrock, Programmer
Mr. Paul Flood, Programmer

Project Title: Intermediate Science Curriculum Study

General Nature of Project: Development of 7-9th grade curriculum in science emphasizing individualized, self-paced learning.

Objectives: 7-9th grade science for all students.
Physics, Chemistry, Biology, Earth Science.
Structured to independent experimentation.

Population: 7-9th graders, ages 12-15 (all ability levels)

Procedures:
General Design: Linear with branching for remedial and enrichment.

Analysis: To be determined.

Data to be collected and
method of collection: Taped responses to be analyzed for specific content and process factors in addition to general analysis of ca and wa and latency.

Expected Results: Revision of textual materials.

Titles of CAI courses used in Project: ISCS

Auxiliary or special materials to be used:
Supplementary record text for written responses.
Audio visual - flip pad diagrams for lab instructions.

Calendar:

Project Starting Date: Fall, 1966

Expected Completion Date: Summer, 1971

Date of First Machine Usage: October, 1966

Type of Use: Program entering

Anticipated Total Time per Student: 180 hours

Number and Length of Student Sessions: 1 hour (2/day)

REMARKS:

COMPUTER-ASSISTED INSTRUCTION CENTER

FLORIDA STATE UNIVERSITY

PROJECT INFORMATION FORM

1500 SYSTEM

Date November 15, 1967 Project Number 0004

Project Director: Ted Wilson
Other Project Personnel: Dr. T. Smith, Committee Chairman; W. A. Kennedy, Dr. Duncan Hansen.

Project Title: Interaction of examiner attitude with praise and blame.

General Nature of Project: Control for examiner influences in praise and blame studies by replacing him with a computer.

Objectives: Demonstrate the influence of examiner attitude in verbal reinforcement experiments.

Population: 100 19-year old FSU sophomores. 50 males and 50 females from the introductory psychology ccurse.

Analysis: 4x4x2 ANOVA Lindquist Type III design

Data to be collected
and method of eollection: Response latencies, number of errors.

Expected Results: A positive attitude will enhance the influence of praise; a negative attitude will enhance the influence of blame.

Auxiliary or Special materials to be used: None.

Calendar:
Project Starting Date: 11/27/67 Expected Completion Date: March 68
Date of First Machine Usage: 11/28/67
Anticipated Total Time per Student: 1 hour
Number and Length of Student Sessions: One 1-hour session

Remarks:

COMPUTER ASSISTED INSTRUCTION CENTER

FLORIDA STATE UNIVERSITY

PROJECT INFORMATION FORM

Date November 1, 1967 Project Number 0005

Project Director: Dr. T. A. Smith and Dr. Duncan Hansen

Other project personnel: Mr. John Hedl - graduate student co-ordinator

Project Title: Attitudes to Teaching Methods

General Nature of Project: To assess attitudes of students in various types of instruction (lecture, discussion, reading, and CAI reading). An attempt will be made to determine which of the treatments aided learning the most.

Objectives:

Population: 30 Ss from the Ed. Psy. 317 class to be used on 1500 system

Sample: 150 Ss total in the experiment.

Procedures:

General Design:

Analysis: Standard Statistical Procedures

Data to be collected and method of collection:

Expected Results: More positive attitudes to computer-assisted instruction as compared to the traditional teaching methods (lecture, reading, and discussion).

Titles of CAI courses used in Project: Essay

Auxiliary or Special materials to be used: No

Calendar:

Project Starting Date: Dec., 1967 Expected Completion Date: April 1, 1968

Date of First machine Usage: Dec. 1, 1967 Type of Use:

Anticipated Total Time per Student: 1 hour

Number and Length of Student Sessions: 30 students will be run on the system

Dates:

Coding: (a) Begun December 1967

(b) Completed December 10, 1967

Debugging: (a) Begun December 10, 1967

(b) Completed

Student Testing: (a) Begun

(b) Completed

Remarks:

COMPUTER-ASSISTED INSTRUCTION CENTER

FLORIDA STATE UNIVERSITY

PROJECT INFORMATION FORM

1500 SYSTEM

Date November 16, 1967 Project Number 0006

Project Director: Dr. Thomas R. King, major professor
Other project personnel: Mr. J. Clark Weaver, minor professor
Mrs. Marsha Markle, author. Mr. Walt Blomquist, CAI editor and advisor

Project Title: An Experimental Thesis Study as partial fulfillment of a Master of Arts Degree in Public Address, Speech Department.

General Nature of Project; Linear program designed to teach beginning students the basic steps of speech preparation.

Objectives: The course will be approximately 230 frames. The objectives are to develop and test the effectiveness of a CAI presentation of programmed learning of basic speech preparation.

Population: College students in a freshman level beginning speech course.

Sample: Group I: Experimental, 25 college students enrolled in Speech 105 at FSU during Spring quarter, 1968 who will receive the CAI treatment.

Group II: Control, 25 students in Speech 105 who will not be exposed to the CCAI program.

Analysis: Student response analysis, pre- and posttests on the information included in the program, and judges' ratings of the speeches.

Data to be collected and method of collection: Students' responses to questioning on the content of the program and judges' ratings of the speeches.

Expected Results: It is expected that those who are exposed to the program will score significantly higher on the content examination than those who are not exposed to the program. The results of the performance examination are anticipated.

Auxiliary or Special material to be used: None.

Calendar:

Project Starting Date: 8-67 Expected Completion Date: 3-68
Date of First Machine Usage: 3-1-68
Anticipated Total Time Per Student: 3 to 4 hours
Number and Length of Student Sessions: 2 to 3 visits, 1 to 2 hours each

Remarks: General Design - Pretest of the information included in the program given to both the experimental and control groups. Experimental group exposed to the program. Control group is not. Posttest of information in program is administered to both groups. In addition, both groups will be required to take a performance examination to see if the subjects can apply what they have learned. The control group will also give the speeches. The speeches will be three minutes in length. The speeches will be videotaped. Judges, composed of instructors in the Speech Department, will view these speeches and rate them.

COMPUTER-ASSISTED INSTRUCTION CENTER

FLORIDA STATE UNIVERSITY

PROJECT INFORMATION FORM

1500 System

Date August 16, 1967 Project Number 0007

Project Director: Dr. Frank Benham

Other Project Personnel: Dr. Henry Lippert

Project Title: Kuder

General Nature of Project: Administration and scoring of Kuder Preference Record

Analysis:

Data to be collected
and method of collection: Collected and displayed on-line.

Auxiliary or Special materials to be used: None.

Calendar:

Project Starting Date: 8-67

Anticipated Total Time Per Student: 30 minutes

Number and Length of Student Sessions: 1 session

APPENDIX C

SYSTEM UTILIZATION REPORT

July 1, 1967 through December 30, 1967

1440 System Usage

TOTAL TIME FOR:	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
CAI	179.81	78.36	178.72	321.90	300.09	169.38
REASSEMBLY	3.09	.86				
COURSE LISTING	.67			.20		.90
AUTOCODER PROGRAMS	22.30	20.71	13.34		.67	.74
OTHER HOUSEKEEPING	27.63				32.37	40.39
TOTAL SYSTEM TIME	233.50	100.07	187.37	349.53	343.13	211.41
DOWN TIME	6.02	9.00	7.33	8.58		

APPENDIX C (continued)

HOURS OF TERMINAL USAGE

COURSE CODE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
ADDSUB				33.09	155.56	
ARTHIS	.13					
CAINT		44.00	17.24			
CHEM	.30					
COMMA	.30					
COMNUMII	85.53					
COMNUMST	21.01					
CONSOWEL	57.65	23.78	57.33	456.71	159.24	45.32
EDTEST	41.57		1.33	1.92		
FORTRAN	1.50		15.90	1.58		
FSUCW	89.17			7.67	16.83	16.83
FSUTEST	6.73					
GAMEPROB						11.17
JHCP	1.70					
LEARN			3.42	136.05	73.42	12.75
LISTGEN			1.25			
LOCKHEED	.75					
MISSOURI		10.33		2.00		
NOMADIS	.32					
NSGLSI	.43					
OHMSLAW	.35					
PHYSDEMO						2.09
PHYSICS	3:30		1.50	280.45	291.12	371.93
PHYTEST	32.92					
PROOF	1.58				79.95	
PSYSTUDY	56.34					
TESTREF	.27					
TESTSTAT	.82					
WELCOME	102.36			4.08	.25	
TOTAL TIME USED	504.03	78.11	281.80	1199.61	838.58	646.05
DOWN TIME					85.75	22.51
AVAILABLE TIME	1078.86	470.16	1065.96	1930.86	1673.58	1005.30
PERCENT UTILIZATION	60.08	27.04	26.44	62.13	50.09	64.26
PROCTOR TERM. USE	144.19	49.04	185.33	276.06	62.00	168.91
REMOTE USE	89.91		14.92	90.63	96.55	29.39
TOTAL TERMINAL TIME USAGE	738.13	127.15	482.05	1566.30	997.13	844.35

APPENDIX C (continued)

HOURS OF 1500 USAGE

COURSE CODE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
DAVE*			.58			
ISCS			253.80	348.34	235.88	101.37
KFH*			12.33			
KUDER			8.00		1.25	
P107			205.15	313.20	309.73	146.44
PSY2			5.84	98.18	3.79	4.09
GAMES**			21.91		40.81	5.10
MONITOR				11.50		
ESSAY					5.00	13.01
THESI					7.09	7.88
MAT						9.00
TEST						13.78
TOTAL TIME USED			508.61	771.22	598.38	300.67
DOWN TIME						00.00
AVAILABLE TIME						
PERCENT UTILIZATION OF TIME						
TOTAL TIME UTILIZED						

* TESTING PROGRAM
** IBM DEMO PROGRAM

Appendix D

DEMONSTRATION REPORT

July 1, 1967 through December 30, 1967

COMPUTER-ASSISTED INSTRUCTION CENTER

	Number of Terminals Used	Total Number Attending
Florida State University		
Dr. Ernest Burkman, 511 Class	8	20
Dr. Mildred Swearingen, Ed.Adminis.Class	6	20
Dr. Marian Black, Ed. Administration Class	6	40
Dr. William Malloy, Supervision Class	2	8
Dr. Eugene Nichols, Math Education Class	4	10
Dr. Timothy Smith, Exper. Psychology Class	4	11
Dr. Frances Hall, Phys. Ed. Research Class	4	13
Dr. Thomas King, Speech Class	3	6
Mr. Jay Knippen, Business Education Class	10	40
Miss Valerie Chamberlain, Home Ec Class	4	15
Dr. Raymond E. Schultz, College Teaching	4	15
Dr. Peter Everett, Physical Ed. Class	4	10
Dr. John Champion, University President	1	3
Dr. William Quinly, Educational Media	8	18
Mr. Jim Swanson, Placement Bureau	5	22
Mr. Mike Beaudoin, Information Services	8	20
Other faculty, staff, and students	8	32
IBM		
On site	10	20
Remote		
University of Tennessee		
University of Ohio		
National Science Foundation Institute	12	30
Social Studies Institute	12	30
Chipola Junior College - Elementary and Secondary Teachers, Marianna, Florida	6	18
Florida Department of Public Welfare	2	7
Florida Department of Education	5	12
L. W. Singer Company	1	4
University of Florida, Gainesville, Fla.	10	25
Lillian Ruediger School, Sixth grade Tallahassee, Florida	16	73
Public School Supervisors of Charlotte, N. C.	5	9

Participating in the preceding demonstrations were representatives from the following organizations in addition to those already identified:

U.S. Office of Education
Leon County Board of Public Instruction

Participants in the preceding demonstrations (continued)

SACS, Paris, France
University of Utah, Salt Lake City, Utah
Southeastern Regional Laboratory, Tallahassee
Florida State Department of Education
Governor's Educational Commission
Clovis, New Mexico High School Faculty
Florida State Board of Regents
Leon County Public Schools, Instructional Services Department
University of Aachen, Germany
General Electric Corporation
North Carolina State, Elizabeth City, North Carolina
Connecticut University, Storrs, Connecticut
Stanford Medical College, Stanford, California
IBM, Paris, France
Atlanta Journal, Atlanta, Georgia
Commission on College Physics
Swiss Federal Institute of Technology, Zurich, Switzerland
French National Institute of Applied Sciences, Lyon, France
Bristol University, Bristol, England
University of Texas, Austin, Texas
Milgo Electronics Corporation, Miami, Florida
Brigham Young University, Provo, Utah
University of Cincinnati, Cincinnati, Ohio
Miami Dade Junior College, Miami, Florida
W. B. Saunders Publishing Company
University of Georgia
Information Sciences, Melbourne, Florida
Carleton College, Northfield, Minnesota