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AN EVALUATION OF COMPUTER MANAGED INSTRUCTION IN NAVY TECHNICAL TRAINING

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The purpose of this project was to develop and evaluate a Computer-managed Instruction (CMI) system that would be less expensive than Computer-assisted Instruction (CAI), would provide a frequency of interaction that falls somewhere between that provided by CAI and that normally provided by CMI, and would handle some of the clerical and administrative burdens that are normally imposed by student-paced instruction. More specifically, a system was developed that would make assignments, grade tests, provide feedback to the student, and provide some of the information needed for the effective control and management of a large-scale system of student-paced instruction. Both the instruction and testing took place off line.

The system was evaluated in two short courses taught at the Naval Air Technical Training Center, Memphis. It was compared to (1) classroom instruction and (2) a system of student-paced instruction that was based on the training materials and tests developed for the CMI system, but which substituted "manual" operations for certain of the operations provided by the computer in the CMI system.

It was found that the use of either form of student-paced instruction led to a reduction in training time of approximately 50% and to slightly higher scores on criterion-referenced tests of student knowledge. There were no substantial differences between the two student-paced systems in terms of training effectiveness. There were several factors which precluded a precise comparison between the two student-paced systems in terms of either cost or cost avoidance, but both were substantially less expensive than current CAI systems.

FOREWORD

This research was performed as part of subproject P13 (Computer-managed Instruction) under Advanced Development Objective 43-03X (Education and Training Development). The subproject was initiated in response to a Technical Development Plan submitted by the Chief of Naval Air Technical Training. The work was done under the joint sponsorship of the Chief of Naval Air Technical Training (later, the Chief of Naval Technical Training) and the Naval Personnel and Training Research Laboratory (later, the Navy Personnel Research and Development Center). Active support and assistance was provided at many levels within the training and research chains of command.

The initial research software package was developed under contract with Memphis State University, primarily by Mr. B. Aimes, Mr. R. Dodd, and Mr. C. Atkins. Modifications of the system were provided by Mr. C. Beckman, Mr. G. Johnson, and Ms. M. Nix of Memphis State University, and by Mr. R. Potts, Mr. D. Harvill, and DP1 D. Kaipus of the project staff. Additional modifications and support in the operation of the system were provided by Mr. C. Tilly and the CMI group from the Naval Air Station, Memphis, Data Processing Department.

The Naval Air Technical Training Center, Memphis, and, in particular, the personnel of the Aviation Familiarization Course and the Aviation Mechanical Fundamentals Course, deserve much of the credit for the success of the project. Many school personnel participated activiely in the derivation of course objectives and the design of training procedures. They provided the actual training for all students involved in the evaluation of the system.

Most of the course materials were prepared by the following people:

Mr. J. Andre	Mr. M. Evans	TDCS W. Saulsberry
AMS1 L. Atteberry	ADJ1 J. Fielder	ADJC D. Sewell
Ms. R. Berry	AT1 H. Fortner	Ms. M. Smith
AVCM M. Clemons	ADJ2 W. Knight	AMSC M. Smittle
Ms. S. Ely	TD1 W. Mitchell	Ms. V. Weymouth
ATC G. Erland	ADJ1 D. Morey	PHC C. Wright
TD2 G. Evans	TDC D. Ramey	

All authors played a variety of roles in the development and evaluation of the system; they have been listed alphabetically.

JAMES J. CLARKIN
Commanding Officer

SUMMARY

Problem

Student-paced instruction has been shown repeatedly to provide dramatic reductions in training time with no loss in student proficiency. However, the effective management of large-scale systems of student-paced instruction places heavy burdens on both the classroom instructor and higher levels of management. The purpose of this study was to evaluate a system in which the computer is used to reduce some of these burdens.

Background

There have been a number of reports on computer applications to training or education in the last few years. Most of them have covered some form of Computer-assisted Instruction (CAI) in which there is a one-to-one ratio between students and terminals and in which instructional materials are stored in the computer. These studies have shown CAI to be an effective but rather expensive training technique. There have also been some studies of Computer-managed Instruction (CMI) in which computer terminals are shared by a number of students and in which most of the instructional materials are stored off line. In general, the CMI studies have been limited to civilian educational settings, and interactions between the student and the computer have been infrequent (e.g., intervals of days or even months).

Approach

The purpose of the present project was to develop and evaluate a CMI system that would be less expensive than CAI, would provide a frequency of interaction that falls somewhere between that provided by CAI and that normally provided by CMI, and would handle some of the clerical and administrative burdens that are normally imposed by student-paced instruction. More specifically, a system was developed that would make assignments, grade tests, provide feedback to the student, and provide some of the information needed for the effective control and management of a large-scale system of student-paced instruction. Both the instruction and testing would take place off line.

The system was evaluated in two short courses taught at the Naval Air Technical Training Center, Memphis. It was compared to (1) conventional classroom instruction and (2) a system of student-paced instruction that was based on the training materials and tests developed for the CMI system, but which substituted "manual" operations for certain of the operations provided by the computer in the CMI system. This latter system was called Instructor-managed Instruction (IMI).

Results

It was found that the use of either form of student-paced instruction (i.e., CMI or IMI) provided a reduction in training time of approximately 50% and to slightly higher scores on criterion-referenced tests of student knowledge. There were no substantial differences between the two student-paced systems in terms of training effectiveness. There were several factors which precluded a precise comparison between the two systems in terms of either cost or cost avoidance, but both were substantially less expensive than current CAI systems.

Conclusions

The data from this study suggest that both the CMI system and IMI system are cost-effective training techniques. This particular CMI system contained a number of "manual" elements that could be eliminated. The IMI system, on the other hand, was dependent on the computer in several respects, and the elimination of this support might have seriously degraded the system's efficiency. Because of these overlapping areas, among other reasons, a choice between the two systems requires a consideration of factors beyond those reflected directly in data gathered during the evaluation. On the basis of such considerations, the Naval Technical Training Command has chosen to proceed with the higher level of computer support (CMI).

There are many features of the CMI system used during the evaluation that were based on arbitrary decisions rather than empirical evaluations of alternatives. It is probable that refinements, based on empirical evaluations, could substantially improve the system efficiency.

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AN EVALUATION OF COMPUTER-MANAGED INSTRUCTION IN NAVY TECHNICAL TRAINING

BACKGROUND

During the mid-1960s, considerable work was initiated in the area of adaptive instruction mediated by computers. A major part of this work used a tutorial mode in which instruction was carried on by means of a dialogue between the computer and the student. This type of instruction usually was referred to as CAI (Computer Assisted Instruction, or Computer Aided Instruction). Other applications of the computer in the instructional process had been conceived, but, on the whole, had not been developed to an appreciable extent. One of these computer applications has been termed Computer Managed Instruction (CMI). CMI sought to retain as many of the advantages of tutorial CAI as possible, while holding the cost of the instructional system to a minimum. The economic advantages of such a system were to be accomplished primarily through increased use of off-line instruction and a reduction in the number of interactions between the computer and the student.

In fiscal year 1968 the project which was to become the Navy's primary undertaking in the area of CMI was initiated jointly by the Chief of Naval Air Technical Training and the Navy Training Research Laboratory Branch Office, Memphis. Certain historical aspects of the project, including funding support from several sources, are described briefly in Appendix A. The objective of the project was to test the feasibility of the CMI concept through the development and evaluation of a CMI system suitable for use in a large-scale technical-training environment. The present report is a description of this effort.

GENERAL ORIENTATION

The term CMI has been applied to a wide diversity of systems. Many of these systems have focused on the support of rather high-level administrative functions while providing little or no immediate support for the management of the instructional process itself. The CMI system developed under the current project differs from those applied to administrative functions in that it focuses on the direct management of the student's interactions with the instructional materials and on the support of certain functions that are intimately associated with these interactions. It provides relatively little in the way of support at the higher levels of management. This emphasis reflects the allocation of limited resources to what is felt to be the more interesting and controversial class of problems. It does not imply that computer support of certain purely administrative functions is unimportant or that there is any basic incompatability between the two kinds of support.

The emphasis described above is obviously quite similar to the emphasis found in most CAI systems. As mentioned previously, the initial approach to this particular CMI system grew out of a consideration of the ways in which the cost of tutorial CAI could be reduced without seriously degrading effectiveness. A brief review of these considerations may provide a useful introduction to the system that was actually developed under this project.

One of the first major changes to be considered was the presentation of the actual instructional material off line. This would radically reduce the amount of material that must be stored, retrieved, and displayed by the computer. Without additional changes in other aspects of the system, however, a simple change of this kind would necessitate a rather complicated and cumbersome system for the location and retrieval of these off-line materials.

The second major change to be considered was a reduction in the number of interactions between the student and the computer. Most interactions in the tutorial mode are devoted to testing the student and, on the basis of these tests, providing him with either new or remedial instructional material. Although certain CAI systems provide fairly sophisticated ways to handle these interactions, there have been many programs written in which most or all interactions are handled by techniques that are functionally identical to those available in standard programmed instruction. It was felt that if interactions of this kind were handled off line, the major effect would be on the strictness of control (i.e., does the student really do what he is supposed to do), rather than on the actual form of the interaction. Studies with teaching machines have shown that there are many instructional situations in which strictness of control is not particularly important.

If the student-program interactions for moderately large blocks of instructional material could be handled off line, the problems of locating this material and of shifting back and forth between it and a computer terminal would be greatly reduced. The primary advantage, however, would be a system in which a number of students share a single terminal.

The remaining considerations were directed toward changes that would have lesser effects on either costs or effectiveness. Within a system of the type discussed in this report, for example, most of the interactions between the student and the computer would take the form of dispersed blocks of test materials that would provide both strict control of performance and the basis for diagnosis, assignment, and tracking by the computer. These tests could be taken on line at the terminal or they could be taken off line, with student responses recorded in machine-readable form. The latter alternative was selected for the system used during the evaluation. This placed some limitations on the type of questions and responses that could be handled gracefully, but it also kept the student from monopolizing the terminal during the time when he was reading questions, thinking about his answers, and entering his responses. This, in turn, increased the number of students that could share a single terminal.

In summary, an instructional system was designed in which most of the instructional materials would take the form of off-line, self-administered packages or modules, and most of the testing would be done off line, with answers recorded on machine-readable answer sheets. The computer would be used for such things as test scoring, diagnosis of student deficiencies, assignment of tests, assignment of new and remedial instructional materials, tracking of students through the materials, and preparation of various reports required for student management. Computer terminals would be shared by a number of students.

The following section describes the system used during the evaluation. Minor changes have been made since the evaluation, and there will be others in the future.

SYSTEM DESCRIPTION

Assignment Patterns

A CMI course consisted of a collection of instructional modules. A student could register for the course under one of several patterns. The pattern provided a means for controlling the assignment of modules. It determined which modules out of the total set would actually be assigned, the general sequence in which the modules would be assigned, and which modules had to be completed successfully before certain others could be assigned.

Learning Guides

The computer communicated with the student by means of Learning Guides. These guides had several general elements, including the following:

1. Heading

The heading contained information such as date, time, course identification, and the student's name, social security number, learning center, and carrel number.

2. New Assignments

This element referred the student to a learning module and a test to be taken at the completion of the module. It indicated the volume and page where the test could be found, the test identification number that the student was to put on his answer sheet, and, when a latent image answer sheet was to be used, the form of the answer sheet and the letter that would indicate a correct response. It also contained any special instructions that might be required for the module in question. Although the module test volumes were available to the student when needed, the end-of-course exams had to be obtained from the instructor. Trainees were monitored, and were required to remove training materials from the carrels while taking tests.

3. Remedial Assignments

This element contained much the same information as the one for new assignments. However, in most cases, the student was told the part or parts of the module on which he had failed to meet a criterion, and was assigned tests that cover only these parts. When the student had taken a specified number of remedial tests in a given area without meeting the criterion, he was told to report to the instructor for more assistance in that particular area. The tests used for both new and remedial assignments were randomly selected without replacement from among sets of parallel tests.

4. General Feedback

The student was informed when he had completed a module and when he had completed certain blocks of modules. The system has a capability for providing question-by-question feedback, but this capability was not used during the period of the evaluation.

Answer Sheets

Students communicated with the computer by means of optically-readable answer sheets. In the heading of these sheets were blocks for the written and coded identification of both student and test. At the time of the evaluation only two types of answer sheets were being used. The first was a simple five alternative, 50-question, multiple-choice answer sheet that was used for end-of-course tests and special inputs (e.g., following shop work). The second answer sheet was similar to the first, but was printed with a special ink so that when an answer alternative was rubbed with a special crayon, one of five letters appeared. Since letters could not be scanned by the equipment being used during the evaluation, when the student made an error he was required to make a pencil mark in an error box at the beginning of the answer line. There were 15 basic patterns for these latent image answer sheets, and since any one of the five letters could be designated as correct, there were 75 answer patterns available. The cost was $0.016 per sheet, in quantity.

The system has capabilities for accepting other than multiple-choice responses, but these capabilities were not being used during the evaluation. When constructed responses were required as, for example, in the preparation of a Maintenance Action Form, the student was instructed to recode his responses into a multiple-choice format.

Records and Reports

The computer maintained records, for each student, of when modules were assigned, when tests were submitted, which questions were missed, and when modules were completed.

Information was provided, either for individual students or for all students, on current assignments and the time at which each had been made. Data on student aptitude (Basic Test Battery Scores) were used to form multiple regression equations that could be used to predict the student's position within the course after various periods of time within the course. The difference between actual position within the course and predicted position within the course was used as the basis for a daily roster of (1) students who should be sent to night school, and (2) students who were in danger of being sent to night school if their performance did not improve (Johnson, Salop, & Harding, 1972). A daily roster was also provided that listed predicted time to course completion for each student in the course. Finally, each student who completed a course was assigned a grade that represented a weighted average of his performance on the end-of-course examination, time in the course, and, when appropriate, performance in the shop.

Hardware

During the period of the evaluation, the system was run on a Xerox Data Systems Sigma 9 computer located at Memphis State University. This computer had 256,000 characters of internal storage and four disk pack drives providing an additional 100 million characters of external storage. This computer was dedicated to Navy use during regular training hours, and was backed up by a second Sigma 9 computer that was normally used by the university itself.

Four remote batch terminal clusters were used during the evaluation. One supported the two CMI learning centers, one supported five "non-CMI" learning centers in which the same material was being taught (including two that were used in the evaluation), one supported a CMI learning center in the Basic Electricity and Electronics portion of the Avionics Technician course, and one was used for developmental work and troubleshooting. Each of these clusters consisted of a Data 100 Corporation terminal, Model 78, supplemented by an Optical Scanning Corporation optical mark reader, Model 100DC, and card punch, Model 521. This terminal configuration could accept approximately 40 answer sheets per minute and could produce learning guides at the rate of about 300 lines per minute. It was estimated that each terminal could support up to 200 students.

PROCEDURES

Courses

The evaluation was done in two relatively short courses, the Aviation Familiarization Course, Class P (AFAM), and the Aviation Mechanical Fundamentals Course, Class P (AMFU). The AFAM course provided training on a number of general topics related to aircraft, aircraft handling, and aircraft carriers. It also provided separate training for Navy and Marine Corps students on aviation ratings or MOSs and the organizational structure of aviation units in the two services (for a complete outline, see

Appendix B). The AMFU course provided training on topics that are common to a variety of maintenance jobs in the aviation community--for example, the use of common aviation hand tools, corrosion control, and various elements of the Naval Aviation Maintenance Program (for a complete outline see Appendix B). In their original forms, the AFAM course was 2 weeks and the AMFU course, 4 weeks.

Specific training objectives were not available for the original AFAM and AMFU courses. Project personnel worked with school personnel in the derivation of the objectives that would be needed for the development of instructional materials for the CMI system. The objectives were subsequently adopted by the schools, and new courses were developed that were oriented specifically toward the teaching of these objectives. The new courses were intiated several months prior to the beginning of the evaluation, providing ample time for revision and for the instructors to become familiar with the new lessons. The revised AFAM course was 1 week, and the revised AMFU course, 2 weeks.

Individualized Instructional Materials

The courses were divided into modules, each covering a set of related training objectives. Average training time on thes modules varied from approximately 15 to 120 minutes. There were 12 modules in the AFAM course and 20 in the AMFU course.

All modules, except certain shop modules that were taught by means of slide-tape programs, were taught by means of programmed instruction booklets. A variety of programming techniques were used. To capitalize on the system's capability for remediation, a concerted effort was made to avoid overprogramming. However, the need for remediation differed considerably from module to module. Data from a sample of 100 students who took both courses indicated that in the AFAM course there was an average of .25 remedial assignments per student per module (with a range over modules of .00 to .97), and an average of 2.65 remedial assignments on the final comprehensive examination. The AMFU course averaged .65 remedial assignments per student per module (with a range over modules of .01 to 1.98) and an average of 12.34 remedial assignments on the final comprehensive examination.

Each program contained a self-test covering all objectives. If a student felt that he might already know the material taught in the program, he could look at this self-test and determine whether or not he should read the program. The self-tests were not graded, but the student was told that he should be certain of his ability to pass these tests before he took the tests that would be submitted to the computer.

Most of the instructional materials were developed by Navy enlisted men who had attended a 13-day instructional programmers course taught at NATTC Memphis. They worked under the direct supervision of a civilian training specialist.

Training Methods

Several features of the CMI system used during the evaluation were the result of constraints that had been encountered during the system's development or of fairly rapid adaptations made in response to deficiencies discovered during the initial large-scale implementation of the system in the schools. The reasons for certain procedures used during this period can be understood only within this historical context.

The system operated in the remote batch mode. This type of operation was originally determined by hardware limitations that existed early in the development. These hardware limitations affected the software, and this, in turn, influenced the selection of new hardware, even after the original limitations had ceased to exist. Because of the delays imposed by the batch operation itself and the time spent in transporting answer sheets and learning guides between the individual learning centers and the central terminal site, there was a considerable wait between the student's submission of an answer sheet and his receipt of a response from the computer. To minimize lost time, the student was provided alternative modules on which he could work while waiting for the computer's response. He was given an initial assignment of several modules and was assigned a new module whenever he completed an old one.

The original implementation in the schools indicated that these procedures were fairly effective in keeping the student engaged in constructive learning activities, even though there were still cases, particularly if he received a number of remedial assignments near the end of a course, when he would simply have to wait. However, there were other problems that arose from the multiple assignments themselves. If something went wrong, if the student forgot or misplaced an assignment, if he miscoded an answer sheet, if answer sheets stuck together while going through the scanner, or if the computer simply failed to evaluate an answer sheet, the failure would often remain undiscovered until long after it had occurred. In such cases the student would eventually find himself with nothing to do while awaiting further assignments that were actually blocked by a missing prerequisite. When it was finally discovered that something must have gone wrong, the student and instructor might spend as much as several hours trying to locate and correct the deficiency.

Block assignments, the manual checking of both answer sheets and learning guides, and the limited use of instructor-assigned remediation were all introduced as short term solutions to the problems described above.

Computer-Managed Instruction

The CMI instruction was given in two learning centers, an 80-student center and a 49-student center. Instruction took place in individual carrels or in a shop area adjacent to the center. Students remained in the same carrels through both courses. The two learning centers were serviced by a single terminal located in the same building.

As an aid in checking answer sheets against learning guides, the instructional modules were generally grouped into blocks of from three to five modules each. The block would be assigned as a unit and the student would retain his answer sheets until he had completed all modules in the block. He would then take both the learning guide and answer sheets to the instructor who would check the answer sheets for coding errors and make sure that a sheet had been submitted for each assignment.

The instructor maintained a folder on each student in which was kept previously generated learning guides that covered new blocks of material and pending remedial assignments. When the student turned in one assignment, he was given a new learning guide. The old learning guide was retained in the folder until a response was received from the computer.

A runner would periodically pick up student answer sheets from the learning center and deliver them to the terminal room. He would also deliver learning guides from the terminal room to the learning center. When a learning guide was brought to the learning center, the instructor would check it against the old learning guide in the student's folder to make sure that a response had been received for each of the answer sheets that had been submitted. When the computer indicated that the student had successfully completed all modules in a block, the original learning guide for that block was discarded from the folder.

To avoid delays resulting from an extended series of remedial assignments, the instructor himself would make the assignment when a student required more than the initial remedial assignment provided by the computer. The instructor was given a guide that contained grading standards and the detailed information needed to assign both tests and answer sheets.

Instructor-managed Instruction

It was originally intended to have a control group which would be taught by individually-paced instruction, but in which all or most of the functions provided by the computer under CMI would be provided by the instructors. To avoid imposing serious administrative burdens on the school personnel, however, a moderate level of computer support was eventually provided. This treatment will be referred to as Instructor-managed Instruction or IMI.

IMI instruction was provided in two learning centers that were similar to those used for CMI, an 80-student and a 57-student center. All instructional materials and tests were exactly the same as those used for CMI.

Most features of the IMI management system were quite similar to those of the CMI system. The main differences were that all tests except the end-of-course examination were evaluated by the instructor, and all assignments except the initial remedial assignments following the end-of-course examination were made by the instructor. Modules were grouped into blocks and students submitted answer sheets for the complete block, just as they did in the CMI system. Individual folders were maintained on each student. Initial assignments were made by means of a set of pre-printed learning guides that were kept in each student's folder. The instructors evaluated the answer sheets and made remedial assignments on the basis of information provided in guides of the same general type as those used by the CMI instructors in making repeated remedial assignments.

Each of the IMI students was actually registered in a modified CMI system that provided rosters of the students in each learning center, scored the end-of-course examinations and provided the initial remedial assignments on these examinations, kept track of the amount of time that the student spent in the course, and provided a final grade for the course. These two centers, plus three additional IMI learning centers which were not included in the evaluation, were served by a single terminal.

Conventional Instruction

Conventional Instruction (CI) was provided in six classrooms, each containing a section of from 20 to 25 students. Two new sections, one of Navy students and one of Marine students, started each Monday. Instruction was by means of lectures and discussions, supplemented by films, charts, and transparencies. Each student was provided with a workbook that contained a complete list of the objectives taught in each lesson, together with sample test questions of the kind provided on the self-tests of the CMI and IMI program. The student could answer the questions during the class or in the barracks at night. The preceding day's answers were checked by the instructor each morning. A student who did poorly on the end-of-course examination could be sent back to repeat all, or, in the case of AMFU, part of the course.

Subjects

The subjects used in the evaluation were selected from the population of students who entered the AFAM/AMFU sequence between 30 April and 14 June 1973, and who were scheduled for subsequent assignment to the Basic Helicopter Course, Class C, or to one of the following Class A courses: Avionics Technician, Aviation Structural Mechanic S (Structures), Aviation Structural Mechanic H (Hydraulics), Aviation Structural Mechanic E (Support Equipment), Aviation Machinist's Mate J (Jet Engine), Aviation Machinist's Mate R (Reciprocating), Aviation Support Equipment Technician Electrical, Aviation Support Equipment Technicial Hydraulics and Structures, or Aviation Support Equipment Technician Mechanical. Students needed to make up conventional sections and to fill vacancies in the CMI or IMI learning centers were randomly selected from the pool of students available at any given time; the remaining students were assigned to learning centers that were not used in the evaluation. These procedures led to variations in the number of students trained under the different methods. A minimum of 142 Navy students and 99 Marine students completed training under each method.

Criteria

The following criteria were used in the study:

1. Drops

Students were separated into three categories: (1) those who successfully completed both the AFAM and AMFU courses, (2) those who were dropped from one or the other of the two courses because of difficulties with the material (lack of knowledge, interest, or aptitude), and (3) those who were dropped from one or the other of the two courses for reasons unrelated to the courses themselves (discipline, medical, etc.). Students in the latter category were eliminated from further consideration. This variable is simply the percentage of students dropped because of difficulties in learning the material.

2. Time to Completion

In all versions of the courses, this variable consisted of normal classroom time (including time during setbacks in the conventional sections), plus time spent in night school.

3. Percentage Correct

For both courses, the percentage correct consisted of the percentage of items that the student got right the first time he attempted the end-of-course examination. These examinations provided an exhaustive coverage of all objectives except the performance objectives taught in the shop portions of the AMFU course. The AFAM test for Navy students contained 220 items; and for Marine students, 182 items. The AMFU test contained 336 items for both Navy and Marine students. The CMI and IMI students were given remedial assignments on any areas in which they failed to meet criteria. The improvement that resulted from those remedial assignments is not reflected in the Percentage Correct scores, but the time required was included in the Time to Completion scores. The improvement resulting from setbacks in the conventional versions of the courses was included in the scores.

4. Shop Grade

The AMFU course contains several shop exercises, each of which is scored by the instructor in a detailed checklist. Errors are weighted in accordance with standardized estimates of importance. This variable was a linear transformation of the total score on these checklists.

5. Attitude I

Upon his completion of the AMFU course, each student was given an 11-item questionnaire on his attitude toward both courses. Each item was in a 5-point Likert format, with 0 representing a very unfavorable response, 2 representing a neutral response, and 4 representing a very favorable response. This variable was the simple average of the 11 items. Questions used are given in Appendix C.

6. Attitude II

Each student in the CMI and IMI sections was also given an 8-item questionnaire on his attitude toward the instruction he had received relative to his attitude toward conventional instruction. Question format and scoring was similar to that used for Attitude I. Questions used are given in Appendix C.

7. Delayed Retention

All items on the AFAM and AMFU end-of-course tests were split between two complementary delayed retention tests. Each of the students from the evaluation who went into the Basic Helicopter Course or into one of the Aviation Machinist's Mate or Aviation Structural Mechanic courses was given one or the other of these delayed retention tests approximately 6 weeks after his graduation from the AMFU course. This variable consists of the percentage of items that the student answered correctly.

8. Class A School Grade

This variable was simply the final average in the subsequent Class A school for students from the evaluation groups who went into the Basic Helicopter Course or into one of the Aviation Machinist's Mate or Aviation Structural Mechanic courses. It was used as a criterion because some of the material taught in the AMFU course is viewed as prerequisite material for these courses.

RESULTS

Most analyses were done by ANOVAs using unweighted means. In these cases, the means of the cell means are reported rather than the means of the raw data. A number of the analyses used week-of-entry as one of the independent variables. This was done primarily as a guard against fluctuations in the quality of student input or unexpected administrative changes. Most analyses also used student aptitude as an independent variable. For Navy students, this variable consisted of the simple sum of scores on the General Classification Test, the Arithmetic Test, the Mechanical Test, and the Clerical Test. For Marine students, This variable consisted of the simple sum of scores on Verbal Expression Test, the Arithmetic Reasoning Test, the Mechanical Aptitude Test, and the

Pattern Analysis Test. Previous research has indicated that these composites correlate with the various dependent variables used in the evaluation of a level that approaches those provided by multiple correlations. In the case of Navy students, all students were divided into three groups of approximately equal sizes by counting down on this variable. A similar procedure was used in the case of certain analyses on the Marine students. However, for most analyses the Marines were divided into only two groups to avoid cells containing less than two students.

Differences discussed in this section are reliable at the .01 level. Differences between levels of aptitude, unless specifically noted, are all reliable at this level. Contrasts between individual treatments were made by means of what Weiner (1962) refers to as the Tukey (a) test. The actual tables for the ANOVAs are in Appendix D. Tables of cell means are in Appendix E.

Tables 1 and 2 provide separate summaries of the results for Navy and Marine students. However, in most cases the patterns are quite similar, so both can be discussed at the same time.

Drops

The differences in drops were tested by means of X2 and were found to be unreliable. However, these figures may not provide an unbiased or objective index of training effectiveness. The standards used to evaluate marginal students in the CMI and IMI centers were based in part on training time, and differed from those used in classroom instruction (CI). Although each of these standards was objective, it is quite possible that they were not equally stringent. For a student to be dropped for academic reasons, he first had to be identified as performing inadequately in terms of the standards referred to above, and must then have been recommended as a drop by his instructor and at each of several ascending levels of review. There may have been considerable differences in the subjective judgments that formed the basis for these recommendations.

AFAM Time to Completion

The AFAM times for CMI and IMI students were quite similar, ranging from 31% to 33% of the times required by CI students. The average variability within CI cells was smaller than the average variability within the CMI and IMI cells, as might be expected, but the F ratios were quite large. Separate analyses of CMI and IMI students indicated no reliable differences between these two training methods.

In the overall analyses, there were statistically reliable Training-Method-by-Week interactions for both Navy and Marine students. This was the result of a holiday which led to an accelerated, 4-day course for the CI groups that were trained that week. Week-by-week means are shown in Appendix E. Aptitude effects were not statistically reliable in the overall analysis of Marine students, but they were reliable in the analysis that was limited to CMI and IMI students.

TABLE 1

PERFORMANCE OF NAVY STUDENTS

	Training Method		
	CMI	IMI	CI
Drops (%)	5.5	6.3	2.1
AFAM Time (hrs)*	10.5	10.3	33.6
AFAM % Correct*	96.4	95.3	89.7
AMFU Time (hrs)*	39.7	38.3	73.2
AMFU % Correct*	94.0	93.5	87.6
Shop Grade*	89.8	87.0	93.3
Attitude I	2.7	2.7	2.7
Attitude II	2.7	2.8	-
Delayed Test % Correct	78.8	75.3	74.7
"A" School Grade	78.4	77.0	77.7

Note--
*Both CMI and IMI differ from CI, $p < .01$

TABLE 2

PERFORMANCE OF MARINE STUDENTS

	Training Method		
	CMI	IMI	CI
Drops (%)	9.2	7.0	7.5
AFAM Time (hrs)*	11.7	10.3	34.4
AFAM % Correct *	95.3	94.1	91.0
AMFU Time (hrs)*	41.0	41.3	70.3
AMFU % Correct*	93.3	92.2	87.6
Shop Grade*	89.8	88.2	93.6
Attitude I	2.9	2.8	2.7
Attitude II	3.0	2.9	
Delayed Test % Correct	78.1	75.5	69.8
"A" School Grade	78.2	76.2	77.0

Note--
*Both CMI and IMI differ from CI, $p < .01$

AFAM Percentage Correct

All groups had scores above 89% on this variable. The CMI and IMI scores ranged from three to seven percentage points higher than those of the CI students. In all cases, the differences were statistically reliable. It should be remembered, though, that the CMI and IMI scores do not reflect the improvement that came about as the result of remediation following the initial administration of the end-of-course examination. For a nonsystematic sample of 36 CMI students, the substitution of scores on tests following remediation for scores on those portions of the end-of-course examination that prompted the remediation led to an increase from 97.7% to 99.0% in AFAM and from 96.1% to 99.0% in AMFU (the original scores for this sample were somewhat higher than those for the total CMI sample).

The analysis of the data from Navy students was complicated by two statistically significant interactions. One was a three-way interaction that seemed to arise from an Aptitude-by-Week interaction (for which there was no obvious explanation) within the CI method that was not present within the other methods. The other was a Training-Method-by-Aptitude interaction that was due to a larger difference between medium and high aptitude students for the CI method than for the CMI and IMI methods. At least part of this interaction was probably the result of a simple ceiling effect, since a difference as large as that found for the CI method would have required scores over 100% in both the CMI and IMI methods. A similar but less pronounced pattern was found for the Marine students. The latter fell short of statistical significance.

AMFU Time to Completion

Again, the times for the CMI and IMI students were quite similar, but in this case they ranged from 54% to 60% of the times required by the CI students. As was the case with AFAM times, variability within the CI cells was smaller, on the average, than variability within the CMI and IMI cells, but the F ratios were quite large. Separate analyses of CMI and IMI students indicated no reliable difference between these two training methods.

There was a reliable Aptitude-by-Week interaction for the overall analysis on Navy students that seemed to arise from a different pattern, over weeks, for low aptitude students than for middle or high aptitude students, but for which there was no obvious explanation. This interaction was not reliable for Marine students, nor was it reliable when the analysis was limited to CMI and IMI students.

AMFU Percentage Correct

Again, all groups had fairly high scores, but in each case they were slightly lower than those obtained in the AFAM course. As a result, the differences between the students in the individually paced courses and the students in the CI course were roughly the same as those found previously. Again, all were statistically reliable.

Shop Grade

This is the only variable on which there were reliable differences favoring the CI group. The largest of these differences was approximately six percentage points. For the Marines there was a statistically significant Training-Method-by-Week interaction that was largely the result of fluctuations in the CI group that were completely out of phase with those in the CMI and IMI groups. Part of the differences between methods, as well as the interaction, may have been due to differences in the grading standards used by the relatively few instructors who scored this work. The difference between CMI and IMI students was statistically reliable for the Navy students, but not for the Marine students. The differences between levels of aptitude fell short of statistical significance for the Marine students.

Attitude I

There were no reliable differences between methods on this variable. For all groups, attitudes toward the assigned training method were somewhat closer to favorable than to neutral. Responses to specific questions can be found in Appendix C.

Attitude II

There were no reliable differences on this variable, not even in aptitude. It is interesting that these students indicated at least a mild preference for individually-paced instruction, even though they were no more favorable than the CI group on Attitude I. Responses to specific questions can be found in Appendix C.

Delayed Retention

In all cases the CMI and IMI students had scores that were higher than those of the CI students, but only in the case of the CMI and CI Marines was the difference reliable. The average difference between the individualized groups and the CI groups on the delayed tests was within .7 percentage points of the average difference found on the end-of-course tests, a finding which lends no support to the fear that material which is learned rapidly will also be forgotten rapidly. The failure to find more reliable differences on this variable was probably due in part to the large variability within groups. For the Marines, even aptitude levels failed to differ reliably.

In general, these scores were 15 to 20 percentage points lower than the corresponding scores on the end-of-course tests. Part of this loss was probably due to a lack of involvement on the part of some students. Some students who had obviously not tried were retested and made substantially higher scores. Previous research in which the retention testing was monitored by the instructors who originally taught the material indicated a much smaller loss.

Class A School Grade

There were no reliable differences between the various groups on this variable.

Costs

Although costs are not results in the same sense as the preceding criteria, they are one of the most important elements of an evaluation. At the outset it was felt that many of these costs could simply be recorded as the project went along, but it soon became obvious that most of the costs recorded in this manner would be contaminated by factors that were either accidental or associated with the unique problems of an initial developmental effort. In most cases informed estimates of cost will provide a more valid basis for judging the long-term cost effectiveness of the present system, or for extrapolations to other systems.

Preparation of Instructional Material

This cost will be roughly the same as the cost of preparing conventional programmed instruction. Estimates of 100 manhours per hour of instruction are fairly common. It will probably be possible to prepare material somewhat more rapidly because of the reliance on lean programs coupled with systematic remediation, but this advantage will probably be more than offset by the need for preparing multiple forms of the end-of-module tests.

Coding

The effort involved in coding a module for the computer will vary greatly as a function of module content and the instructional strategy that is followed in teaching the module. Some modules, for example can be tested by means of very short tests (even one-item tests in extreme cases), and performance following remediation can be tested by parallel versions of the same test. In other cases, very long tests will be needed to cover specific areas within the module, and provisions must be made for selecting from among a number of alternative forms of remediation.

The modules included in these courses were moderately complex, and preparation for the computer probably required an average of from 5 to 10 manhours each. This includes coding, card punching, and debugging.

ADP

One of the major distinctions between the CMI and IMI systems is the cost of ADP equipment and personnel. Unfortunately, the actual costs of the two systems were almost completely confounded during the period of the evaluation. Even had they not been, it would have been difficult to arrive at costs that could be used as a realistic basis for extrapolation, since use fluctuated widely during the period covered. There also tended to be an under utilization of the system for training purposes because of the developmental nature of the program.

As part of the information required for the procurement of a Navy computer to be used in support of CMI, the Computer Center at the Naval Air Technical Training Center, Memphis, developed estimated costs for various numbers of students. These costs covered the computer itself, terminals, and both military and civilian ADP personnel. In general, the cost per student decreased with increases in the total number of students. For a 7-hour training day the estimated cost was $.75 per hour for 500 students, and about $.20 per hour for 5000 students. If a like number of students were added in a second shift, the cost per student hour would be reduced by at least 40%. Cost estimates for computer hardware and personnel to support the two courses in an operational setting have been reported in a somewhat different format by Mayo (1973, 1974).

Similar estimates were not developed for the IMI system, but the cost would be fairly substantial. In fact, the IMI system used during the evaluation was actually a less elaborate CMI system.

Instructors

During the period of the evaluation, the student to instructor ratio was approximately 10:1 in both the CMI and IMI learning centers. This was about the same as the ratio that existed in the conventional course. However, there were several respects in which the CMI system being used during the evaluation differed from the CMI system that is being implemented on a general basis at the Naval Air Technical Training Center, Memphis.

Serious problems were encountered in running the original version of the CMI system. Since there was not enough time to rectify these problems through major modifications of the software, it was decided to mitigate their effects by having the instructors duplicate, or assume entirely, certain functions that had originally been allocated solely to the computer. These additional duties accounted for about a third of the instructor time spent in the CMI learning centers.

At the present time there are several 80-student learning centers in the Basic Electricity and Electronics portion of the Avionics Technician course that are being run under CMI by five instructors. This more favorable student-instructor ratio may be due in part to the fact that students interact with the computer less frequently in this course. However, the major factors are probably the use of single, sequential assignments and a smaller, less expensive, classroom terminal that provides near-instantaneous responses. These features eliminate the need for the instructor to monitor the answer sheets and lesson guides, or to provide remedial assignments. Some incidental data on instructor attitudes toward CMI can be found in Appendix C.

DISCUSSION AND CONCLUSIONS

There are three main points that should be stressed concerning the outcome of this evaluation, all of which have already been touched on briefly. The first is the rather arbitrary nature of the CMI system that was used during the evaluation, the second is the lack of differences between CMI and IMI in terms of training effectiveness, and the third is the efficiency of these training systems relative to alternative training systems.

This evaluation should not be interpreted as a definitive evaluation of CMI. It is an evaluation of one particular approach to CMI, at one particular stage of its development, and in one particular training context. The system developed under this project was the first attempt to design a system for this type of application, and it suffered from many problems of the kind that should be expected in any initial development effort. Although the system afforded capabilities that were never used, it lacked others that would have improved results, simply because neither time nor resources were available for all the needed modifications. The new classroom terminal now in use, for example, provides an efficient solution to many of the problems that were encountered during the initial implementation of the system in the schools, but this terminal and the software needed to run it were not available in time to be used in the evaluation. There have been many improvements in the system since its inception, and there is no reason to doubt that there will be substantial improvements in the years to come. Nevertheless, the system that existed at the time of the evaluation proved to be highly effective for training.

The IMI system was just as good as the CMI system in terms of training effectiveness, and, in view of the similarity of the two systems from the student's point of view, any other finding would have been surprising. Under such circumstances it might seem reasonable to conclude that the level of computer support provided by the IMI system is a more reasonable choice than the level of computer support provided by the CMI system. To justify the contrary, it is necessary to go beyond the data provided by the formal evaluation.

The argument for the higher level of support is based upon two main assumptions. First, if the instructors can be relieved of the jobs of tracking the students through the course, evaluating answer sheets, and making remedial assignments, then it should be possible to effect substantial increases in the student-instructor ratio. Some of the reasons why this could not be done during the evaluation have already been indicated, as have the reasons for believing that some of the difficulties which existed during the evaluation have subsequently been corrected by system modifications.

The second assumption is that a moderately high level of computer support will be required to manage any large scale system of individualized instruction. Such a level was certainly provided for IMI during the evaluation. In the kind of situation under consideration here, it is also reasonable to assume that there will be decreases in the marginal costs of increased computer utilization. Estimates of these costs and cost avoidances were used by the Computer Center at the Naval Air Technical Training Center, Memphis, to justify the higher level of support on the grounds that the decrease in the cost of instructors would more than offset the increased costs of computer support required to score all answer sheets, make all assignments, and track the student through the course.

The higher level support also provides the basis for a number of additional capabilities that would not be available with the lower level support. For example, it provides a greater flexibility in tailoring both course content and training methods to the needs and capabilities of individual students. It also provides the data required for the optimum allocation of scarce instructional resources, the rapid identification of students who are having difficulties, and the systematic improvement of instructional materials.

For comparisons other than those between CMI and IMI, it will be helpful to attach at least crude monitary values to reductions in training time. The students and instructors who are tied down in formal school training are not immediately available for use in meeting the Navy's operational commitments. Any reduction in the number of men in these categories (assuming no reduction in the number or proficiency of graduates) should provide a comparable reduction in the total number of men required by the Navy. Training time can be converted directly to student and instructor man-years, and reductions in these man-years should represent a source of real savings. In the following discussion, the estimated savings are based on annual personnel costs as determined by the Comptroller of the Navy at the time of the evaluation. These were taken to be $5890 for students (E-3), and $9697 for instructors (E-6).

Before turning to the savings provided by CMI, it might be noted that considerable savings were provided by the revision of training objectives, one of the by-products of the research project. Even if there had been no individual pacing of instruction, the revision of the conventional courses to meet these new objectives provided a 50% reduction in training time, and, therefore, in the number of students under training at any given time. With an average input of 300 students per week, which is quite conservative, this would have provided a cost reduction of approximately six million dollars a year.

The individual pacing of instruction, whether by CMI or IMI, provided an additional reduction in average training time of about 50%. This, in turn, provided an additional cost reduction of approximately three million dollars a year. This represents almost twice the total cost of the research project, including the salaries of military personnel, and is about five times the annual cost of supporting a CMI system in these particular schools, including all ADP costs and the cost of special instructional equipment.

In conclusion, it might be worthwhile to compare both the cost and benefits of this CMI system with similar data that have been reported for CAI systems. Probably the most meaningful comparisons can be made with applications of CAI within military training situations. One of the first (IBM, 1968) reported a reduction in training time of only 11.5%. With revisions of this same material, the savings increased to 20.1% (Longo, 1969). Finally, as more material was programmed, the savings increased to better than 35% (Longo, 1972). All of these studies were done using the IBM 1500 system to teach the early portions of an Army course in electroncis. In another study in which the 1500 system was used by the Navy to teach the early portions of a course in electronics, a savings of about 45% was reported (Ford, Slough, and Hurlock, 1972). Finally, studies in which the Lincoln Training System was used to teach an early portion of an Air Force course in electronics report savings that range from 37% (Lincoln Laboratory, MIT, 1972) to 50% (Lincoln Laboratory, MIT, 1973; Training Research Applications Branch, Keesler AFB, 1973).

On the surface, the overall reduction in training time found in this study would seem to be competitive with the reductions reported for CAI, but, as is usually the case, there are complications. On the one hand, the control for variations in training objectives was somewhat more stringent in this study than it was in certain of the CAI studies. On the other, it is quite possible that the materials taught in this study provided somewhat greater opportunities for reductions in training time than did the material on electronics taught in the CAI studies. Relative advantages or disadvantages of CAI, in contrast to CMI, will not be apparent until comparisons are made in terms of alternative training treatments, instructor to student ratios, types of instructional material, ease of instructional modification, and other pertinent variables. The decision to select any instructional procedure, including CMI or CAI, dependsupon many factors including training objectives, criticality of the training and other situational variables which may or may not enter into direct dollar cost. Because of these considerations, it is difficult to generalize about the relative values of CMI and CAI.

In terms of cost per training hour, CMI of the type described here seems to enjoy a clear advantage over CAI. The costs of the system, even in its limited application to the two courses used in the evaluation, are less than the costs that have been projected for CAI in the next few years. (See Ford, Slough, and Hurlock, 1972, for a discussion of CAI costs.) The costs for a large-scale CMI implementation of the kind that has been initiated at the Naval Air Technical Training Center, Memphis, are far less.

THE IMMEDIATE FUTURE

At the time this report is being prepared, action pertaining to CMI is taking place on two fronts within the Navy. The first of these is the use, improvement, and expansion of the present system by the Navy Technical Training Command. CMI is being used currently at the Naval Air Technical Training Center, Memphis, in the Aviation Fundamentals Course, Class P (a successor to the two courses described in this report), the Basic Electricity and Electronics Course, Class P, and in the Aviation Machinist's Mate J (Jet) Course, Class A. The Memphis computer is also being used to support CMI in Basic Electricity and Electronics Course, Class P, at the Service School Command, San Diego. The current on-board load under CMI is approximately 2500 students. Plans have been made for a sizeable expansion of the system to other courses, both in Memphis and in remote locations.

The second front in which CMI is being applied is that of additional research. A project designed to test the feasibility of CMI as a means for providing an entire technical training sequence tailored to the requirements of specific billets in the fleet has recently been completed. Another ongoing project is designed to test the feasibility of using minicomputers for applying CMI to shipboard personnel.

In addition to these two major CMI efforts a number of Exploratory Development projects are oriented toward an improved technology of individualized instruction. The results of these efforts should help to increase the efficiency of CMI.

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APPENDIX A

HISTORICAL ASPECTS OF THE CMI PROJECT

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The CMI project was initiated in fiscal year 1968 as a joint undertaking of the Chief of Naval Air Technical Training and the Navy Training Research Laboratory Branch Office, Memphis. Support from external sources for the first year consisted of funds provided by the Assistant Secretary of Defense (Manpower and Reserve). Since fiscal year 1969, the primary support of the CMI project has come in approximately equal amounts from the Navy's Advanced Development Objective 43-03X (Education and Training) and from the Chief of Naval Technical Training. ADO 43-03X has supported research and development aspects of the project. The Chief of Naval Technical Training has funded development of instructional material, renovation of spaces for computer-based instruction, and computer support in the on-going training situation.

In terms of actual dollar amounts, \$866K was received from ADO 43-03X. The Chief of Naval Technical Training provided \$210K, plus the services of approximately six Navy petty officers for the duration of the project. The Naval Air Systems Command provided \$130K for training equipment, and the Assistant Secretary of Defense (Manpower and Reserve), \$70K in the initial phase of the project. The Naval Air Technical Training Center, Memphis, provided two Navy petty officers for most of the project, plus assistance in the derivation of training objectives. NATTC also made available students in the numbers needed throughout the development and evaluation of the CMI system. The Naval Air Station, Memphis, provided one civilian computer analyst during most of the project, and several computer and terminal operators during the latter part of the project.

APPENDIX B

CONTENT OF AFAM AND AMFU COURSES

APPENDIX B

Content of AFAM and AMFU Courses

AFAM Modules

1. The Military Aircraft Designation System

2. Basic Theory of Flight and Aircraft Nomenclature

3. Aircraft Handling Crews, Securing Devices, and Safety in Line Operations

4. Aviation Support Equipment

5. Aviation Rating Familiarization or Marine Aviation Occupational Fields

6. Aircraft Carriers

7. Aircraft Firefighting

8. Naval Aviation Organization or Marine Aviation Organization

9. Standard Aircraft Taxi Signals

10. Basic Aircraft Systems

11. Aircraft Cleaning

12. Aviation Fuels, Oils, and Hydraulic Fluid

AMFU Modules

1. Introduction to the Naval Aviation Maintenance Program
2. The Work Unit Code Manual
3. Maintenance Requirements Cards
4. Corrosion
5. Mechanics of Heat and Gases, Static Electricity and Basic Hydraulics
6. Addition, Subtraction, Multiplication, and Division of Fractions
7. Addition, Subtraction, Multiplication, and Division of Decimals
8. The Support Action Form
9. The Maintenance Action Form - Single Copy
10. Aircraft Hardware
11. Wrenches
12. Screwdrivers and Pliers
13. Measuring and Marking Tools and Drills
14. Vices, Files, and Hacksaws
15. Punches, Chisels, and Striking Tools
16. Maintenance and Operation Manuals
17. The Maintenance Action Form - Multi-Copy
18. Torque Wrenches
19. Shop I
20. Shop II

APPENDIX C

STUDENT ATTITUDE QUESTIONNAIRE

APPENDIX C

Student Attitude Questionnaire

Questions 1 through 11 were common to all three training methods and were used as the basis for the Attitude I scores. For questions 1, 3, 4, 7, 9, 10, and 11, the last alternative was assumed to be indicative of a favorable attitude. For questions 2, 5, 6, and 8, the first alternative was assumed to be indicative of a favorable attitude.

Questions 12 through 25 were common to CMI and IMI. Questions 12 through 19 were used as the basis for the Attitude II scores. For questions 12, 15, 18, and 19, the last alternative was assumed to be indicative of a favorable attitude. For questions 13, 14, 16, and 17, the first alternative was assumed to be indicative of a favorable attitude.

The percentages under the treatment columns are based on a nonsystematic sample of 201 students from each treatment.

Student Questionnaire

The following statements apply to the way you felt while you were a student in the AFAM/AMFU courses. We are interested in your opinion on each of these statements. Do not hesitate to put down exactly how you feel about each item. Your honest opinion will be most helpful.

Mark on your answer sheet the number of the response that most nearly represents your reaction to each of the statements below. Do not write on this booklet.

	% Responses CMI	IMI	CI
1. I felt challenged to do my best work.			
1. Strongly disagree	1	1	2
2. Disagree	5	2	7
3. Uncertain	4	6	15
4. Agree	59	63	56
5. Strongly agree	31	27	19
2. I was concerned that I might not be understanding the material.			
1. Strongly disagree	12	9	7
2. Disagree	42	35	30
3. Uncertain	11	9	17
4. Agree	29	38	34
5. Strongly agree	6	8	12
3. I felt uncertain as to my performance relative to the performance of others.			
1. All the time	7	8	5
2. Most of the time	14	14	9
3. Some of the time	34	38	28
4. Only occasionally	22	22	33
5. Never	22	17	25
4. I felt myself just trying to get through the courses rather than trying to learn.			
1. All the time	1	1	1
2. Most of the time	6	4	3
3. Some of the time	13	17	14
4. Only occasionally	28	40	27
5. Never	52	38	55

	CMI	IMI	CI
5. I tried to learn as much as I could.			
1. All the time	63	55	54
2. Most of the time	29	40	37
3. Some of the time	5	3	6
4. Only occasionally	2	0	2
5. Never	0	2	1
6. I felt pushed.			
1. Strongly disagree	25	18	27
2. Disagree	32	26	47
3. Uncertain	10	14	10
4. Agree	19	31	13
5. Strongly agree	13	10	3
7. The material was easy to learn.			
1. Strongly disagree	1	2	3
2. Disagree	14	16	18
3. Uncertain	16	23	18
4. Agree	54	49	51
5. Strongly agree	14	9	9
8. The material was difficult to remember.			
1. Strongly disagree	12	6	8
2. Disagree	64	57	54
3. Uncertain	8	18	10
4. Agree	13	17	24
5. Strongly agree	2	1	3
9. I felt frustrated by the way these courses were run.			
1. Strongly agree	5	5	5
2. Agree	12	13	6
3. Uncertain	11	13	12
4. Disagree	46	47	55
5. Strongly disagree	26	21	21

	CMI	IMI	CI
10. The material was presented effectively.			
1. Strongly disagree	1	2	3
2. Disagree	5	4	8
3. Uncertain	7	7	4
4. Agree	62	61	64
5. Strongly agree	25	25	20
11. I felt that too much was expected of me.			
1. Strongly agree	2	1	2
2. Agree	6	6	1
3. Uncertain	9	8	6
4. Disagree	54	56	60
5. Strongly disagree	28	28	30
12. I felt I could work at my own pace.			
1. Strongly disagree	5	7	
2. Disagree	15	12	
3. Uncertain	4	8	
4. Agree	48	47	
5. Strongly agree	27	25	
13. The learning was too mechanical.			
1. Strongly disagree	20	23	
2. Disagree	58	60	
3. Uncertain	11	10	
4. Agree	7	4	
5. Strongly agree	3	2	
14. This type of instruction made me feel quite tense.			
1. Strongly disagree	16	12	
2. Disagree	47	45	
3. Uncertain	13	13	
4. Agree	16	22	
5. Strongly agree	7	8	

		CMI	IMI
15.	I would prefer this type of instruction over traditional instruction.		
	1. Strongly disagree	5	7
	2. Disagree	14	12
	3. Uncertain	15	15
	4. Agree	25	37
	5. Strongly agree	41	29
16.	I tried to learn as quickly as I could in this course.		
	1. All the time	57	53
	2. Most of the time	36	37
	3. Some of the time	4	6
	4. Only occasionally	1	3
	5. Never	2	0
17.	I felt that I could have learned just as much without taking so many tests during the courses.		
	1. Strongly disagree	27	31
	2. Disagree	49	41
	3. Uncertain	7	15
	4. Agree	13	10
	5. Strongly agree	4	2
18.	In view of the amount I learned, I would say this type of instruction is superior to traditional instruction.		
	1. Strongly disagree	3	5
	2. Disagree	13	7
	3. Uncertain	19	18
	4. Agree	36	45
	5. Strongly agree	29	24
19.	I would prefer subsequent courses to be this type of instruction rather than traditional instruction.		
	1. Strongly disagree	2	5
	2. Disagree	17	13
	3. Uncertain	16	22
	4. Agree	36	40
	5. Strongly agree	28	19

	CMI	IMI
20. The instructor was available whenever I needed him.		
1. All the time	75	78
2. Most of the time	21	17
3. Some of the time	2	4
4. Only occasionally	2	0
5. Never	0	0
21. One of the main reasons that I worked hard during the day was to avoid being sent to night school.		
1. Strongly agree	8	6
2. Agree	14	17
3. Uncertain	4	5
4. Disagree	44	46
5. Strongly disagree	30	25
22. I felt I would be sent to night school no matter how hard I worked during the day.		
1. Strongly agree	1	3
2. Agree	5	7
3. Uncertain	3	8
4. Disagree	46	44
5. Strongly disagree	44	37
23. I could have learned faster if the room had not been so noisy.		
1. Strongly agree	4	3
2. Agree	11	12
3. Uncertain	9	10
4. Disagree	50	47
5. Strongly disagree	26	27
24. There were occasions when I was at my carrel with nothing to do.		
1. Very often	1	1
2. Often	1	1
3. Some of the time	10	3
4. Only occasionally	34	8
5. Never	54	86

25. I could have learned just as much if I had spent less time in class.

		CMI	IMI
1.	Strongly agree	1	2
2.	Agree	6	1
3.	Uncertain	12	12
4.	Disagree	48	51
5.	Strongly disagree	33	33

APPENDIX D

ANOVA TABLES

APPENDIX D

ANOVA Tables

Navy: AFAM Time (hrs), All Methods

Source	SS	df	MS	F
Trng Meth (TM)	44446.96	2	22223.48	1181.70*
Aptitude (A)	330.87	2	165.43	8.80*
Week (W)	269.44	6	44.91	2.39
TM X A	631.97	4	40.16	2.14
TM X W	160.63	12	52.66	2.80*
A X W	239.20	12	19.93	1.06
TM X A X W	399.29	24	16.64	.88
error within	7917.46	421	18.81	

Note ---
* $p < .01$

Navy: AFAM Time (hrs), CMI and IMI only

Source	SS	df	MS	F
Trng Meth (TM)	2.79	1	2.79	.12
Aptitude (A)	556.19	2	278.09	11.82*
Week (W)	82.06	6	13.68	.58
TM X A	3.42	2	1.71	.07
TM X W	189.54	6	31.59	1.34
A X W	423.34	12	35.28	1.50
TM X A X W	285.42	12	23.78	1.01
error within	7833.82	333	23.52	

Note ---
* $p < .01$

Marine: AFAM Time (hrs), All Methods

Source	SS	df	MS	F
Trng Meth (TM)	26362.10	2	13181.05	603.26*
Aptitude (A)	48.25	1	48.26	2.21
Week (W)	243.53	6	40.59	1.86
TM X A	86.27	2	43.13	1.97
TM X W	469.63	12	55.80	2.55*
A X W	127.45	6	21.24	.97
TM X A X W	371.13	12	30.93	1.42
error within	5353.17	245	21.85	

Note--
* $p < .01$

Marine: AFAM Time (hrs), CMI and IMI only

Source	SS	df	MS	F
Trng Meth (TM)	68.62	1	68.62	4.84
Aptitude (A)	105.17	1	105.17	7.41*
Week (W)	152.23	6	25.37	1.79
TM X A	4.37	1	4.37	.31
TM X W	165.67	6	27.61	1.95
A X W	196.92	6	32.82	2.31
TM X A X W	149.58	6	24.93	1.76
error within	2142.37	151	14.19	

Note--
* $p < .01$

Navy: Number of Errors on AFAM Final Examination, All Methods

Source	SS	df	MS	F
Trng Meth (TM)	15585.79	2	7792.89	93.76*
Aptitude (A)	6844.90	2	3422.45	41.18*
Week (W)	1392.90	6	232.15	2.79
TM X A	2207.19	4	551.80	6.64*
TM X W	2078.27	12	173.19	2.08
A X W	1441.89	12	120.16	1.45
TM X A X W	4423.99	24	184.33	2.22*
error within	34991.79	421	83.12	

Note--
* $p < .01$

Marine: Number of Errors on AFAM Final Examination, All Methods

Source	SS	df	MS	F
Trng Meth (TM)	2259.42	2	1129.71	15.80*
Aptitude (A)	2308.68	1	2308.68	32.28*
Week (W)	357.72	6	59.62	.83
TM X A	244.28	2	122.14	1.71
TM X W	1135.95	12	94.66	1.32
A X W	298.04	6	49.67	.69
TM X A X W	757.55	12	63.13	.88
error within	17377.99	243	71.51	

Note--
* $p < .01$

Navy: AMFU Time (hrs), All Methods

Source	SS	df	MS	F
Trng Meth (TM)	91548.19	2	45774.09	348.89*
Aptitude (A)	18522.64	2	9261.32	70.59*
Week (W)	1679.89	6	279.98	2.13
TM X A	316.83	4	79.21	.60
TM X W	2239.39	12	186.62	1.42
A X W	4456.84	12	371.40	2.83*
TM X A X W	5448.76	24	227.03	1.73
error within	50832.56	417[a]	131.20	

Notes--

* $p < .01$

[a]df and harmonic mean adjusted because of one cell containing single observation

Navy: AMFU Time (hrs), CMI and IMI only

Source	SS	df	MS	F
Trng Meth (TM)	110.88	1	110.88	1.13
Aptitude (A)	13572.96	2	6786.48	69.36*
Week (W)	354.25	6	59.04	.60
TM X A	71.08	2	35.54	.36
TM X W	443.65	6	73.94	.76
A X W	2237.53	12	186.46	1.91
TM X A X W	716.17	12	59.68	.61
error within	28282.60	329[a]	97.84	

Notes--

*$p < .01$

[a]df and harmonic mean adjusted because of one cell containing single observation

Marine: AMFU Time (hrs), All Methods

Source	SS	df	MS	F
Trng Meth (TM)	40259.31	2	20129.65	143.20*
Aptitude (A)	2933.91	1	2933.91	20.87*
Week (W)	898.15	6	149.69	1.06
TM X A	526.95	2	263.47	1.87
TM X W	871.61	12	72.63	.52
A X W	459.97	6	76.66	.55
TM X A X W	638.78	12	53.23	1.87
error within	34017.91	242	140.57	

Note--
*p < .01

Marine: AMFU Time (hrs), CMI and IMI only

Source	SS	df	MS	F
Trng Meth (TM)	2.20	1	2.20	.02
Aptitude (A)	2416.42	1	2416.42	21.57*
Week (W)	889.14	6	148.19	1.32
TM X A	310.07	1	310.07	2.78
TM X W	193.56	6	32.26	.29
A X W	275.56	6	45.93	.41
TM X A X W	408.38	6	68.06	.61
error within	16692.72	149	112.03	

Note--
*$p < .01$

Navy: Number of Errors on AMFU Final Examination, All Methods

Source	SS	df	MS	F
Trng Meth (TM)	35206.22	2	17603.11	102.41*
Aptitude (A)	20946.15	2	10473.07	60.93*
Week (W)	1455.64	6	242.61	1.41
TM X A	1534.78	4	383.70	2.23
TM X W	3482.45	12	290.20	1.69
A X W	759.21	12	63.27	.39
TM X A X W	3108.39	24	129.52	.75
error within	72020.06	419	171.89	

Note--
*$p < .01$

Marine: Number of Errors on AMFU Final Examination, All Methods

Source	SS	df	MS	F
Trng Meth (TM)	15769.63	2	7884.82	42.40*
Aptitude (A)	4492.63	1	4492.63	24.16*
Week (W)	663.16	6	110.53	.59
TM X A	327.79	2	163.90	.88
TM X W	2269.34	12	189.11	1.02
A X W	674.91	6	112.49	.60
TM X A X W	1132.00	12	94.33	.51
error within	45371.72	244	185.95	

Note--
*$p < .01$

Navy: Shop Grade, All Methods

Source	SS	df	MS	F
Trng Meth (TM)	2516.01	2	1258.01	53.78*
Aptitude (A)	404.16	2	202.08	8.64*
Week (W)	155.59	6	25.93	1.11
TM X A	62.62	4	15.65	.67
TM X W	538.87	12	44.91	1.92
A X W	374.75	12	31.23	1.34
TM X A X W	512.31	24	21.35	.91
error within	9848.21	421	23.39	

Note--
*$p < .01$

Marine: Shop Grade, All Methods

Source	SS	df	MS	F
Trng Meth (TM)	1126.16	2	563.08	30.38*
Aptitude (A)	49.18	1	49.18	2.65
Week (W)	154.91	6	25.82	1.39
TM X A	90.16	2	45.08	2.43
TM X W	510.62	12	42.55	2.30*
A X W	161.47	6	26.91	1.45
TM X A X W	349.98	12	29.16	1.57
error within	4541.42	245	18.54	

Note--
*p < .01

Navy: Attitude I Totals, All Methods

Source	SS	df	MS	F
Trng Meth (TM)	30.29	2	15.15	.41
Aptitude (A)	414.17	2	207.08	5.65*
Week (W)	114.89	6	19.15	.52
TM X A	200.51	4	50.13	1.37
TM X W	513.24	12	42.77	1.17
A X W	345.42	12	28.79	.79
TM X A X W	706.23	24	29.43	1.37
error within	10761.14	328[a]	36.59	

Notes--

*$p < .01$

[a]df and harmonic mean adjusted because of two cells containing single observation

Marine: Attitude I Totals, All Methods

Source	SS	df	MS	F
Trng Meth (TM)	114.71	2	57.35	2.00
Aptitude (A)	218.38	1	218.38	7.63*
Week (W)	373.93	6	62.32	2.18
TM X A	55.71	2	27.86	.97
TM X W	383.23	12	31.94	1.12
A X W	186.58	6	31.10	1.09
TM X A X W	358.80	12	29.90	1.05
error within	6294.93	220	28.61	

Note--
*$p < .01$

Navy: Attitude II Totals, CMI and IMI only

Source	SS	df	MS	F
Trng Meth (TM)	28.78	1	28.78	.87
Aptitude (A)	21.32	2	10.66	.32
Week (W)	46.57	6	7.76	.23
TM X A	25.09	2	12.54	.38
TM X W	136.52	6	22.75	.69
A X W	456.75	12	38.06	1.15
TM X A X W	197.69	12	16.47	.50
error within	6925.50	252[a]	33.05	

Note--

[a]df and harmonic mean adjusted because of two cells containing single observation

Marine: Attitude II Totals, CMI and IMI only

Source	SS	df	MS	F
Trng Meth (TM)	12.76	1	12.76	.56
Aptitude (A)	8.78	1	8.78	.39
Week (W)	183.27	6	30.54	1.35
TM X A	80.87	1	80.87	3.56
TM X W	173.12	6	28.85	1.27
A X W	398.40	6	66.40	2.93
TM X A X W	122.13	6	20.35	.90
error within	3085.92	136	22.69	

Navy: Number of Errors on Delayed Tests, All Methods

Source	SS	df	MS	F
Trng Meth (TM)	4771.74	2	2385.87	1.81
Aptitude (A)	13592.09	2	6796.04	5.16*
Test Form (F)	6705.40	1	6705.40	5.09
TM X A	2576.45	4	644.11	.49
TM X F	9303.10	2	4651.55	3.53
A X F	873.87	2	436.93	.33
TM X A X F	3330.13	4	832.53	.63
error within	263653.69	200	1318.27	

Note--
*p <.01

Marine: Number of Errors on Delayed Tests, All Methods

Source	SS	df	MS	F
Trng Meth (TM)	13516.43	2	6758.21	5.51*
Aptitude (A)	8025.78	2	4012.89	3.27
Test Form (F)	1180.60	1	1180.60	.96
TM X A	3937.53	4	984.38	.80
TM X F	3790.61	2	1895.30	1.55
A X F	12.32	2	6.16	.01
TM X A X F	9138.60	4	2284.65	1.86
error within	177875.69	145	1226.73	

Note--
*$p < .01$

Navy: Class A School Grades, All Methods

Source	SS	df	MS	F
Trng Meth (TM)	5287.31	2	2643.66	.88
Aptitude (A)	183928.88	2	91964.44	30.60*
TM X A	16435.76	4	4108.94	1.37
error within	607076.00	202	3005.33	

Note--
*p <.01

Marine: Class A School Grades, All Methods

Source	SS	df	MS	F
Trng Meth (TM)	103.90	2	51.95	1.35
Aptitude (A)	967.39	2	483.70	12.63*
TM X A	37.44	4	9.36	.24
error within	5937.74	155	38.31	

Note--
*p <.01

APPENDIX E

CELL MEANS FOR INTERACTIONS

APPENDIX E

Cell Means for Interactions

Navy: Number of Errors on AFAM Final Examination

Aptitude	Week	Training Method		
		CMI	IMI	CI
	1	6.0	6.1	14.7
	2	5.0	5.2	6.2
	3	7.0	10.8	10.8
High	4	3.6	8.4	6.0
	5	2.7	18.5	16.4
	6	6.2	7.0	14.8
	7	6.0	5.2	19.8
	Avg	5.2	8.7	12.7
	1	8.2	10.3	20.3
	2	6.1	8.4	20.3
	3	9.7	10.8	16.1
Medium	4	6.1	7.7	14.0
	5	7.3	6.0	29.5
	6	8.0	11.9	45.7
	7	8.4	10.9	19.3
	Avg	7.7	9.4	25.1
	1	12.8	22.9	22.8
	2	9.0	14.1	30.3
	3	8.2	14.0	39.5
Low	4	11.3	15.5	22.7
	5	15.2	8.2	30.0
	6	9.8	19.2	32.6
	7	18.3	9.7	35.4
	Avg	12.1	14.9	30.5

Navy: AFAM Time (hrs)

Training Method	Week 1	2	3	4	5	6	7
CMI	10.1	11.0	10.1	11.7	10.7	9.1	10.9
IMI	12.7	9.9	11.4	9.4	9.3	9.9	9.8
CI	32.4	34.6	35.0	34.5	28.3	34.9	35.1

Marine: AFAM Time (hrs)

Training Method	Week 1	2	3	4	5	6	7
CMI	13.1	11.2	10.8	14.6	10.7	9.3	12.6
IMI	9.1	11.8	9.4	10.4	13.1	8.6	9.6
CI	35.0	37.5	34.9	35.0	28.0	34.5	36.8

Navy: AMFU Time (hrs)

	Week						
Aptitude	1	2	3	4	5	6	7
High	46.0	41.3	40.3	41.7	49.3	43.0	39.7
Medium	46.7	49.0	48.0	42.3	53.0	46.7	47.0
Low	65.0	56.3	70.3	52.3	55.7	56.7	66.0

Marine: Shop Grade

	Week						
Training Method	1	2	3	4	5	6	7
CMI	90.0	90.5	93.0	87.0	91.0	89.0	88.0
IMI	88.5	86.5	90.0	90.0	90.5	87.5	85.0
CI	92.0	95.0	91.5	95.5	93.0	94.0	94.5

APPENDIX F

INSTRUCTOR ATTITUDE QUESTIONNAIRE

APPENDIX F

Instructor Attitude Questionnaire

Data on instructor attitudes was not collected during the period of the evaluation. More recently, however, a brief questionnaire was administered to 44 instructors in the Aviation Fundamentals Course, Class P (AFUN), a combination of the old AFAM and AMFU courses, and to 54 instructors in the Basic Electricity and Electronics (BE&E) phase of the Avionics Technician Course, Class A.

In general, attitudes toward CMI were somewhat more favorable in the BE&E course than in the AFUN course. On a summary question which asked the instructors to indicate their feelings about working with CMI, IMI, and CI by placing check marks on lines running from Very Happy (4) through Neutral (2) to Very Unhappy (0), the BE&E instructors had average responses of 2.6 for all three systems, whereas the AFUN instructors had average responses of 2.3 for both CMI and IMI and an average response of 3.0 for CI. When some of the more general questions from the questionnaire (items 1, 2, 3, 4, 5, 7, 8, 10, 11) were scored so that a score of 4 would indicate a very favorable attitude toward CMI and a score of 0 would indicate a very unfavorable attitude toward CMI, instructors in the BE&E course had an average score of 2.3, whereas instructors in the AFUN course had an average score of 1.8. The scores did not seem to be strongly related to variations in amount of previous experiences with CI or in the amount of time that the instructor had spent working in a CMI center.

SAMPLE INSTRUCTOR ATTITUDE QUESTIONNAIRE

Name ______________________________________

Rate or GS level ___________________________

The following questions are designed to find out something about the typical instructor's reaction to CMI. You are asked to provide some additional information on your background and experience, but your answers will be kept strictly confidential. They will not be used to reflect on you as an individual or on a particular learning center. Please think about each question and answer it seriously, since the results can help the Navy in its plans for CMI.

Please seal your completed questionnaire in the attached envelope and take it to the course office for subsequent delivery to S-39.

For each question, circle the letter of the alternative that best represents your opinion.

In what school do you work?

a. AFUN
b. BE & E

How long have you worked in a CMI learning center (or lab)?

a. less than 2 months
b. 2-4 months
c. 4-6 months
d. 6-8 months
e. more than 8 months

Have you remained in the same job for this entire period, or do you rotate from job to job?

a. remain in same job
b. rotate from job to job

If you have remained in the same job, provide a brief description of the job (standard title if there is one).

____

____

Did you ever work in an IMI (individualized but not computer supported) learning center?

a. Yes
b. No

Did you ever teach in a conventional classroom, and if so, for how long?

a. never taught in a conventional classroom
b. 0-1 year
c. 1-2 years
d. 2-4 years
e. more than 4 years

	% Responses	
	AFUN	BE & E
1. On the average, students learn as well in a CMI learning center as they do in a conventional classroom.		
1. Strongly agree	11	15
2. Agree	34	50
3. Undecided	20	13
4. Disagree	25	20
5. Strongly disagree	9	3
2. Most students would prefer a CMI learning center to a conventional classroom.		
1. Strongly agree	11	6
2. Agree	43	26
3. Undecided	25	24
4. Disagree	20	39
5. Strongly disagree	0	6
3. Students in a CMI learning center are less motivated than students in a conventional classroom.		
1. Strongly agree	18	4
2. Agree	30	33
3. Undecided	11	20
4. Disagree	32	37
5. Strongly disagree	7	6

	% Responses AFUN	BE & E
4. Students in a CMI learning center suffer because there is less personal contact with the instructor.		
1. Strongly agree	23	4
2. Agree	32	17
3. Undecided	9	13
4. Disagree	30	52
5. Strongly disagree	4	3
5. The Navy should increase its use of CMI.		
1. Strongly agree	11	17
2. Agree	30	33
3. Undecided	27	35
4. Disagree	20	11
5. Strongly disagree	11	4
6. I would be willing to serve a tour of duty (or take a job) teaching in a conventional classroom.		
1. Strongly agree	27	30
2. Agree	59	50
3. Undecided	9	6
4. Disagree	0	6
5. Strongly disagree	4	9
7. I would be willing to serve another tour of duty (or take another job) in a CMI learning center.		
1. Strongly agree	14	28
2. Agree	47	50
3. Undecided	7	7
4. Disagree	11	7
5. Strongly disagree	20	7
8. I would prefer to work in a conventional classroom rather than a CMI learning center.		
1. Strongly agree	25	6
2. Agree	27	24
3. Undecided	25	44
4. Disagree	11	20
5. Strongly disagree	11	6

9. The instructor's work in a conventional classroom is harder than his work in a CMI learning center.

	% Responses AFUN	% Responses BE & E
1. Strongly agree	14	11
2. Agree	18	13
3. Undecided	18	30
4. Disagree	34	37
5. Strongly disagree	14	6

10. Work as an instructor in a CMI learning center is more boring than work in a conventional classroom.

	AFUN	BE & E
1. Strongly agree	47	9
2. Agree	34	22
3. Undecided	2	13
4. Disagree	9	44
5. Strongly disagree	7	9

11. Much of my technical knowledge is wasted in a CMI learning center.

	AFUN	BE & E
1. Strongly agree	25	2
2. Agree	34	13
3. Undecided	7	9
4. Disagree	32	54
5. Strongly disagree	2	22

12. Instructors should rotate from one job to another within a CMI learning center.

	AFUN	BE & E
1. Strongly agree	41	30
2. Agree	45	57
3. Undecided	7	4
4. Disagree	4	6
5. Strongly disagree	2	2

	% Responses	
	AFUN	BE & E
13. There should be two kinds of people in a CMI learning center, one kind who would handle the relatively routine jobs and another kind who would help the students with their technical problems.		
1. Strongly agree	7	7
2. Agree	23	24
3. Undecided	14	7
4. Disagree	20	37
5. Strongly disagree	32	24
14. I would enjoy preparing instructional materials for use in CMI.		
1. Strongly agree	9	9
2. Agree	11	31
3. Undecided	23	33
4. Disagree	25	17
5. Strongly disagree	32	9

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