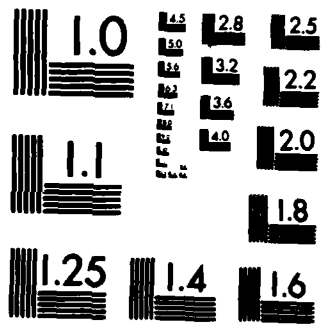
AD-A146 564 COMPUTER-MANAGED INSTRUCTION: THEORY APPLICATION AND SOME KEY IMPLEMENTATION ISSUES(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA M KORBAK MAR 84

1/2

UNCLASSIFIED F/G 5/9 NL



'OPY RESOLUTION TEST CHART

2

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

COMPUTER-MANAGED INSTRUCTION:
THEORY, APPLICATION, AND SOME KEY
IMPLEMENTATION ISSUES

by

Michael Korbak, Jr.

March 1984

Thesis Advisor: Norman R. Lyons

Approved for public release; distribution unlimited

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A146 564
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Computer-Managed Instruction: Theory, Application, and Some Key Implementation Issues	5. TYPE OF REPORT & PERIOD COVERED Master's Thesis March 1984
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Michael Korbak, Jr.	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, CA 93943	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, CA 93943	12. REPORT DATE March 1984
	13. NUMBER OF PAGES 125
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer-Managed Instruction, Computer-Assisted Instruction, Educational Technology, Computers in Education

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Use of computers in education has not materialized to the extent envisioned. In an attempt to better understand the use of computers in the educational arena, this thesis focuses on one viable application called Computer-Managed Instruction. It presents a capsulated examination of what Computer-Managed Instruction is, what it consists of, and what functions it performs. It examines some of the systems currently available to develop the flavor of actual system operation. Also, this thesis explores key student-

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-LF-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(Block 20 continued)

teacher implementation issues of Computer-Managed Instruction, providing some insight into the slow acceptance and use of computers in education.

Accession For	
NTIS GRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

S N 0102- LF- 014- 6601

Approved for public release, distribution unlimited

Computer-Managed Instruction: Theory, Application, and Some Key Implementation Issues

by

Michael Korbak, Jr.
Lieutenant Commander, United States Naval Reserve
B.S., University of Pittsburgh, 1972

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN INFORMATION SYSTEMS

from the

NAVAL POSTGRADUATE SCHOOL
March 1984

Author: Michael Korbak, Jr.

Approved by: Norman R Lyons
Thesis Advisor

Dan C Boger
Second Reader

Richard L. Elster
Chairman, Department of Administrative Sciences

Kneale T. Marshall
Dean of Information and Policy Sciences

ABSTRACT

Use of computers in education has not materialized to the extent envisioned. In an attempt to better understand the use of computers in the educational arena, this thesis focuses on one viable application called Computer-Managed Instruction. It presents a capsulated examination of what Computer-Managed Instruction is, what it consists of, and what functions it performs. It examines some of the systems currently available to develop the flavor of actual system operation. Also, this thesis explores key student-teacher implementation issues of Computer-Managed Instruction, providing some insight into the slow acceptance and use of computers in education.

TABLE OF CONTENTS

LIST OF FIGURES

I. INTRODUCTION

In the early 1960's, the computer was heralded as the great savior of education. Through computer technology many believed that fascinating, programmable "teaching machines" [Ref. 1] would revolutionize the learning experience and impact significantly the future of education. In fact, for more than 20 years educators have had high hopes for use of computers in their field of endeavor [Ref. 2]. But these expectations never materialized. Instead, the introduction of computerized educational technology has occurred only slowly, and has proven limited and disappointing, particularly when compared with the dramatically rapid advances of computer applications in science, medicine, and industry. Many even sarcastically ask of the whereabouts of education in the computer revolution.

Numerous and diverse explanations have been proposed for this sluggish progress. In addition to factors such as poorly understood learning theories and excessive cost, a recurring theme in the literature is the skeptical, anti-technology attitude of educators, who have endorsed computer technology but fail to adopt it. As one educational consultant claims: "Educators appear to have a deep-set skepticism toward anything that plugs into the wall." [Ref.3] Related factors which always promote such skepticism are confusion and ignorance. Educational technology literature has used a bewildering array of terms, the proliferation of which has virtually rendered these terms meaningless, except to indicate that a computer is involved in some way.

In an attempt to better understand educational computer technology and to diminish the confusion and skepticism in this area, this thesis examines one mechanism of computer-based education, namely Computer-Managed Instruction (CMI). It presents an overview of what CMI is, what it is composed of, and what it does; and to provide insight into its slow evolution and acceptance in education, this thesis explores some key managerial issues of CMI implementation. Several aspects of CMI, albeit important ones, are beyond the scope of this thesis. For example, the CMI design and development process, analysis of feasibility, and the selection/acquisition process are not discussed. Therefore, this thesis is a compilation of the primary attributes of CMI technology, commencing with an historical perspective and definition as provided in Chapter II.

CMI has its basis on individualized instruction, of structuring the curriculum to each individual's needs, goals, and characteristics (e.g., learning styles, media preference, etc.). Chapter III focuses on this aspect and other underlying themes which serve as the theoretical foundation for CMI.

The availability of a computer is a prerequisite to CMI implementation. Beyond this one prerequisite, however, no other common point need exist between two CMI systems. Chapter IV emphasizes the computer component of the CMI system, and includes a comprehensive look at the generic functions of CMI systems. Chapter V then provides an overview of some representative CMI systems to develop the flavor of the features and operation of CMI systems.

Chapter VI examines some key implementation issues of CMI, highlighting those which may be responsible for the evolution of computer technology in education which has proceeded more slowly than envisioned in the early 1960's. Chapter VII is the summary and also provides a glimpse of CMI in the future.

Nearly everyone who has written on the subject of computer-based education agrees that the potential is enormous. The question now is not <u>whether</u> computers will find a place in education but <u>how</u> [Ref. 4]. Computer-Managed Instruction is one such feasible method, and because of its emphasis on providing administrative assistance to the teacher, CMI represents the logical mechanism to break down the educator's skepticism and hopefully hasten computer-based education acceptance and widespread use.

II. BACKGROUND

A. HISTORICAL PERSPECTIVE

In the mid-1950's, while still in its infancy, computer technology entered the world of education. Although first used in universities as a research and administrative tool, computers soon sparked the imaginations of innovative educators who foresaw the possibilities of using computers as instructional tools to individualize instruction. Educators were convinced that schools could teach with the computer as well as about the computer [Ref. 5].

Educators' interest in individualization of instruction had repeatedly arisen in the past, as an effort to overcome the shortcomings of the educational process. But their interest had also waned each time because of the inherent problems and complexities of managing the individualized instruction curriculum.

B.F.Skinner's 1954 article, "The Science of Learning and the Art of Teaching," focused the interest of educators on tailoring the instructional process in a more meaningful way to match the already known differences in student motives and abilities [Ref. 6]. Through the use of programmed learning concepts and computerized teaching machines, educators could indeed attain their elusive goal of individualization of instruction. Skinner's article, specifically, and computer technology, generally, provided the initial impetus toward computer-based education. It wasn't long before the familiar, school child's vacation verse, "no more pencils, no more books, no more teacher's dirty looks," began to be used by people who erroneously assumed that computers would replace the old tools of education and the teachers themselves [Ref. 7].

Computer-Assisted Instruction (CAI) soon became the magical concept that would transform the entire educational field. CAI research laboratories developed nearly overnight. IBM and Systems Development Corporation took the lead in industry, and in universities, famous CAI projects included the Stanford University CAI project, the University of Illinois project called PLATO (Programmed Logic for Automatic Teaching Operation), and the MITRE/Brigham Young University project called TICCIT (Time-Shared, Interactive Computer-Controlled Information Television). [Ref. 8] Through the National Science Foundation and other funding activities, the Federal Government, under the Elementary and Secondary Education Act of 1965, poured millions of dollars into these and other CAI projects [Ref. 9].

Through the 1960's CAI development proceeded at a brisk pace, but a large number of CAI projects that had been initiated with much fanfare just faded away quietly when educators recognized that the full potential of CAI was not going to be realized in the foreseeable future. A 1968 Federal Government study indicated that annual costs of CAI amounted to at least $1000 per student, and summing these costs for all students amounted to CAI costs approaching 80 percent of the total annual public school expenditures [Ref. 10]. Recognizing this as unacceptable, educators began searching for other alternatives of computer use in education.

Computer-Managed Instruction (CMI) represented a logical alternative, because of CMI's less intensive use of the computer and therefore lower costs than CAI. The low-keyed developmental efforts of CMI, however, received very little of the publicity of the kind associated with CAI. It lacked a nationally prominent demonstration project, such as PLATO. It received only a fraction of the educational funds enjoyed by CAI. Consequently, CMI development did not attempt to live up to unrealistic promises, as CAI, but developed and proceeded at only a modest pace. As summarized during a 1974 CMI conference:

> Our thesis is that in the rush to get large numbers of students into an interactive mode on computer terminals, some of the basic potential of computer-managed instruction for contributing to the achievement of instructional goals in schools, colleges, industries, and

> military training centers may have been overlooked. Our suspicion that educational technologists 'missed the boat' by first going for the exciting and exotic CAI applications is not advanced in the spirit of blame or in glorification of hindsight, but in the sense of 'taking stock' of the present situation. [Ref. 11]

Thus, the gradual shift to CMI had begun. Coleman College in San Diego, California characterized the state of educational technology within many universities: as a four year institution specializing in education in the computer field, it experimented with CAI in the mid-1960's, but abandoned the concept in the early 1970's due to extremely high development costs [Ref. 12].

The first papers with any substance which dealt specifically with CMI were published in 1967 (as contrasted with CAI literature first published more that a decade earlier). Five pioneering systems generated considerable interest. Four of these were designed for use in the elementary schools, and included: Individually Prescribed Instruction/Management Information System, Computer Managed Systems of Mathematics Instruction, Program for Learning in Accordance with Needs (PLAN), and Instructional Management System (IMS). The fifth system, Teacher Information Processing System (TIPS), was designed for college level use [Ref. 13]. The military also developed CMI systems within a few years of these first five, with primary ones called: the U.S. Army Computerized Training System (CETS), the U.S. Air Force

Advanced Instructional System (AIS), and the U.S. Navy CMI System [Ref.14].

Subsequently developed CMI systems through the present time have all retained the primary objective of Computer-Managed Instruction, of providing an effective means to manage an individualized instruction program. Most of the systems have proven some degree of viability and effectiveness, but nothing as far-reaching as a revolution has yet occurred in educational technology. Many critical issues still today remain as obstacles for widespread acceptance and use of CMI. The CMI systems will be discussed in Chapters IV and V, and some obstacles to implementation will be presented in Chapter VI.

B. DEFINITION

A study of the literature reveals little agreement on a precise definition for the term "CMI". To this day there remains a great deal of confusion regarding the terminology used for computer use in education. This has resulted to a great extent because of immense and ever-evolving computer capabilities, so that the computer can be used in the administrative and instructional arena of education in many possible ways, under many roles, combinations and variations of roles, and under roles not yet formulated [Ref. 15]. Consequently, examples can be found where several authors use different terms to describe the same activity, or the same term to describe different activities. Figure 2.1 illustrates this proliferation of terminology.

Automated Teaching

Computer-Administered Instruction (CAI)

Computer-Aided Instruction (CAI)

Computer-Aided Learning (CAL)

Computer-Aided Teaching

Computer-Assisted Education

Computer-Assisted Guidance (CAG)

Computer-Assisted Learning (CAL)

Computer-Based Education (CBE)

Computer-Based Instruction (CBI)

Computer-Based Learning (CBL)

Computer-Controlled Teaching

Computer-Directed Training

Computer-Individualized Instruction (CII)

Computer-Managed Instruction (CMI)

Computer-Managed Learning (CML)

Computer-Simulated Instruction

Computerized Instruction

Figure 2.1 Terminology Proliferation

Precise definitions of any of the terms in Figure 2.1 tend to vary in meaning from author to author, with numerous subtleties blurring the issue. This is complicated by changing meanings as educational and computer technology evolves. The effect of this generates confusion and creates a mystique of computer usage in education which hinders its acceptance.

Computer-Managed Instruction is no exception. One simplifying viewpoint, which is based on the evolutionary trends of computers in education, maintains that Computer-Based Education encompasses all the characteristics of Computer-Assisted Instruction and Computer-Managed Instruction. In essense, CBE = CAI + CMI [Ref. 16]. Again, this is only a generally accepted relation, but one which aids in understanding Computer-Managed Instruction.

Therefore, contrasting the two components of Computer-Based Education (CBE) is helpful in building this better understanding of CMI. One definition of Computer-Assisted Instruction (CAI) is

> any teaching process that directly involves the computer in the storage and presentation of instructional materials in an interactive mode to provide and control an individualized learning environment. [Ref. 17]

In a CAI system, the student typically works alone at a computer terminal in a room with multiple terminals.

Keypoints of CAI include:

- The material presented is usually of an instructional nature.

- The student works in real time; the process is interactive and involves a direct communication between student and computer.

- Many workstations are often required due to the interactive individualized nature of courseware.

- Systems using CAI involve management of instruction only to some degree.

- CAI is characterized as "typically intensive" [Ref. 18], concentrating on detailed, highly interactive instruction for a limited segment of course content and a relatively small number of students.

One definition of Computer-Managed Instruction (CMI) of the many cited in the literature is

> a total educational approach in which a computer-based management information system is used to support the management functions performed by the teacher. [Ref. 19]

In a CMI system, the student receives instruction from texts, workbooks, or other media formats, and not directly from the computer. Key points of CMI, which contrast directly to the previously listed CAI points, include:

- The material presented is not of an instructional nature, but consists of tests or educational management tools.

- The student need not necessarily deal in real time with the computer; the computer can be used in a batched or delayed fashion.

- Many students plus the instructor may share a single workstation.

- Systems using CMI have as their sole function the management control of learning.

- CMI is characterized as "typically extensive" [Ref. 20], managing instruction for a large number of students through a large body of course content.

In CAI, the computer actually delivers the instruction - CAI is learning through the computer. Thus, its benefits are inherently for the student. In CMI, the computer does not deliver the instruction - CMI is learning with computer support. Thus, its benefits are inherently for the teacher. It performs the busy work for the teacher, freeing the teacher for activities of guidance, coaching, and motivation.

The role of CMI is to test the student on what he has learned, evaluate whether the learning has been satisfactory or not, prescribe corrective action in cases where the material has not been learned adequately, and control the student moving ahead to new material until the current material has been mastered. CMI includes applications of computer supported analysis that aid the teacher in managing instruction without actually doing the teaching. In short, the computer's role in CMI is that of "evaluator, diagnostician, prescriber, and manager of instructional events." [Ref. 21]

III. THE CMI CONCEPTUAL FRAMEWORK

The theoretical issues which serve as the foundation for CMI have their roots embedded not in computer technology, but in education. CMI is the coalescence of two elements: the computer component and the educational component. The former will be discussed in Chapter IV. This chapter focuses on the latter - the educational component.

One phrase typically encountered in CMI literature is total educational approach, a phrase sometimes incorporated within CMI definitions. So it is not surprising that the basis for CMI rests with issues in education. Therefore, this chapter explores educational concepts relevant to CMI, such as mastery learning, individualized instruction, curricular plans, and instructional models.

A. MASTERY LEARNING

Just as two people may look different, each possesses inherent individual differences of motivation, ability, IQ, etc. With respect to learning, these individual differences together form for each individual unique cognitive styles; i.e., the dominant modes of information processing which individuals employ when perceiving, learning, or problem solving [Ref. 22].

These cognitive styles (with cognitive aptitudes and abilities) then develop an idiosyncratic way of learning for each individual. In educational settings, these idiosyncratic ways of learning are called study habits; in psychological research settings they are called learning strategies, defined as

> human information-processing activities that facilitate acquisition, retention, and retrieval of representational and procedural knowledge in long-term memory. [Ref. 23]

These learning strategies, cognitive characteristics, and individual differences have all been studied extensively. At this time, however, no generally accepted single theory as to how people learn is supported by an overwhelming range of empirical evidence. Many theories even contradict one another. The *statement* "Different individuals learn in different ways, along a variety of dimensions" represents the primary agreed upon point [Ref. 24].

The predominant learning theory supporting the basis for Computer-Managed Instruction is termed mastery learning. In his book, Human Characteristics in School Learning, Benjamin Bloom claims that it is possible for 95 percent of students to learn, with the same levels of mastery, all that is in a current school curriculum. He remarks that

> ...most students can attain a high level of learning capability if instruction is approached sensitively and systematically, if students are helped when and where they have learning difficulties, if they are given sufficient

time to achieve mastery, and if there is clear criterion of what constitutes mastery. [Ref. 25)

Features of mastery learning include:

1. Mastery is explained relative to the specific instructional objectives every student is required to achieve.

2. The instruction itself is structured into clearly defined learning units or modules.

3. Complete mastery of each learning unit is demanded by every student before proceeding to the next learning unit.

4. A diagnostic objectives-referenced test is administered to every student at the end of each learning unit, to provide feedback on the adequacy of the student's learning.

5. Based upon the diagnostic information, a student's original instruction is remediated and/or supplemented so that he can successfully master the learning unit. [Ref. 26]

Advocates of mastery learning contend that individual differences would nearly entirely vanish if this mode of instruction were properly implemented, with the ultimate effect of students achieving a higher level of learning. Only in recent years have scientific studies been conducted to determine whether individual differences would be reduced or eliminated by mastery learning using a CMI system.

Study results indicate that mastery learning through CMI cannot entirely eliminate the consequences of incoming cognitive characteristics. Although all successive students meet or exceed the mastery level of learning for a particular learning unit, they tend to differ in the amount of their achievement in at least some of the instructional units. No method of instruction - not even CMI mastery learning - produces identical instructional outcomes in all students. Indeed, CMI is not a computerized procedure for outputting "student clones". [Ref. 27]

Nevertheless, mastery learning can reduce the effect of individual differences to some extent, although to an as yet unmeasurable extent. Other conceptual aspects of CMI, discussed in this chapter, build upon the five features of mastery learning. It therefore serves as as underlying theme of Computer-Managed Instruction.

B. INDIVIDUALIZED INSTRUCTION

There exist several methods of instruction. As many as twenty different methods have been identified [Ref. 28). Of these, two fundamental categories can be distinguished: conventional and individualized instruction.

Conventional instruction consists of lectures, discussions, group tutoring, etc. in which all students are supposed to learn the same material at the same rate. Conventional instruction has been characterized with the following attributes:

- predetermined group pacing,
- preselected nonvariant media, and
- predetermined nonvariant construction [Ref. 29].

Once established, these characteristics are employed with all group members. A shortcoming of this "lock-step" instruction is its relative inflexibility, particularly with large groups of students. Student differences in cognitive characteristics and learning strategies cause some students to fall behind, others to lose interest or motivation , and produce actual knowledge acquisition on a broad spectrum.

The search for workable educational programs which attempt to take into account student differences has been going on for generations, but only in the 1960's were such programs adopted in a significant number of schools. These programs had different names - the nongraded school, team teaching, individually prescribed learning, the organic curriculum, adaptive education, precision teaching, individualized instruction - but all shared the similar goal, of tailoring the curriculum to the individual learner rather than making the individual learner adjust to the offerings of conventional instruction.

Individualized instruction is an instructional strategy in which all learning activities are designed to accomodate individual differences in background, skill level, aptitudes, and cognitive styles. In effect, it is the mechanism which implements the concept of master learning. It has been characterized by the following attributes:

- release of time constraints; learn at a self-determined pace that is comfortable to the learner,
- choice of instructional material; learner furnished with a wealth of instructional media from which to choose, and
- instruction adjusted to learner's skill levels and learning strategies [Ref. 30].

Many authors literally glorify individualization, yet it does not escape all critics. Derogatory comments include: lack of group interaction, some loss of the inspirational and motivational leadership of a dedicated teacher, and high developmental costs. Implementation of individualization is still limited today, as most of education relegates it to just a philosophical principle.

The primary detractor stems from the seemingly overwhelming amount of information demanded in the individualized instructional system and the corresponding management required to make it work effectively. When all students progress through the same instructional materials at about the same rate, little information is required. When all 30 students in a class, for example, are on page 124 of the arithmetic textbook, that single page number defines where the class is as a whole. Consequently, when this neat and simple process is broken and individual students are allowed to work at different levels and rates, the teacher has 30 times as much information to monitor for that same class. If students are also permitted to progress toward different objectives or toward the same objective through different modes of instruction, the information processing and its management become even more severe. For an individualized program to be viable, support of computer systems designed to assist in information storage, processing, and retrieval has proven essential [Ref. 31].

Individualized instruction has been a prime motivator for CMI development. Many CMI definitions inextricably demonstrate the involvement of CMI with the concept of individualized instruction, such as

> the CMI computer is utlilized as a tool in the management of the information needed by teachers in planning individualized instruction. [Ref. 32]

CMI supports more of the attributes of individualization than any other educational computer supported system, including CAI, which emphasizes the computer for actually delivering the instruction and usually does not provide the learner with the choice of instructional material.

Just as in mastery learning, individualized instruction and CMI have been criticized for not eliminating the individual's learning differences. Educational systems, including all computerized ones designed today, are still unable to fully adapt instructional strategies to each individual and eliminate individual differences as a factor in learning. This is a limitation of psychological and educational research and capabilities, not of computer technology. Irrespective of some deficiencies, individualized instruction (as mastery learning) still serves as an underlying conceptual theme of CMI.

In summary, individualized instruction, when fully implemented, includes the "freedom for the student to ...

1. register and commence the program at any time of any day;
2. enter the program learning sequences at a point determined by his measured entry skill level;
3. proceed through the program at a pace determined only by his capability and determination;
4. select from among a set of instructional media and methods;
5. be measured for achievement of objectives at any time he considers himself ready; and,
6. complete the program whenever he can demonstrate mastery of the objectives." [Ref. 33]

C. CURRICULAR PLAN

The curricular plan represents the building block of the CMI educational program. It defines the subject matter and delimits the scope of the course. The curricular plan generally exists in the form of a set of chapters, modules, units, of behavioral objectives that encapsulate the subject matter content. It results directly from a detailed design process performed by textbook writers, educational research and development centers, and individual teachers.

In CMI, the curricular plans often result from a detailed process called "task analysis" [Ref. 34], in which a task is broken down logically into successively smaller conceptual units until some minimal element is reached. These minimal elements are called units, frames, segments, concepts, or behavioral objectives depending upon one's point of view, although most CMI systems use the term "units" or "modules". In the Navy and some other organizations, task analysis is analogous in principle to Instructional Systems Development (ISD).

Task analysis breaks down the curriculum into learnable, bite-size portions from the learner's point of view. And from the educator's viewpoint, task analysis breaks down the curriculum into useable, workable units which then allows the curriculum manager to restructure or rearrange the sequence of these units, as presented to the learner, into curriculum structures in which the educator feels is most advantageous.

Five different curricular structures are currently employed in the curricular plans of CMI systems, as depicted in Figure 3.1 [Ref. 35]. In a linear structure the student has no options: the total curriculum is arranged in a unit to unit sequence, so that all students start at the first unit and progress sequentially to the last unit.

In a variation of the linear structure called the strand structure, the curriculum is divided into major areas; i.e., strands. Within each of these strands, several units are arranged in linear order. Within a strand the student progresses unit by unit, but now the student may work on a unit within one or more strands concurrently and can be at different places in each strand. Eventually, the student should complete the last unit in each strand.

In the block structure, the curriculum is broken down into major topics, or blocks, and a number of units exist within each block. Within a block, no required order is imposed on the student - he is free to complete the units in the block in any sequence. But the student can move from one block only when <u>all</u> units have been completed within that block.

The fourth curricular structure, a tree structure, is the most sophisticated one and most complex for CMI implementation. Typically, the units appearing at the bottom of the tree (the roots) are considered prerequisites to those units above them. The students can therefore work simultaneously on units on several different branches, on units which may be quite unrelated. He can skip around with regard to units, but must complete

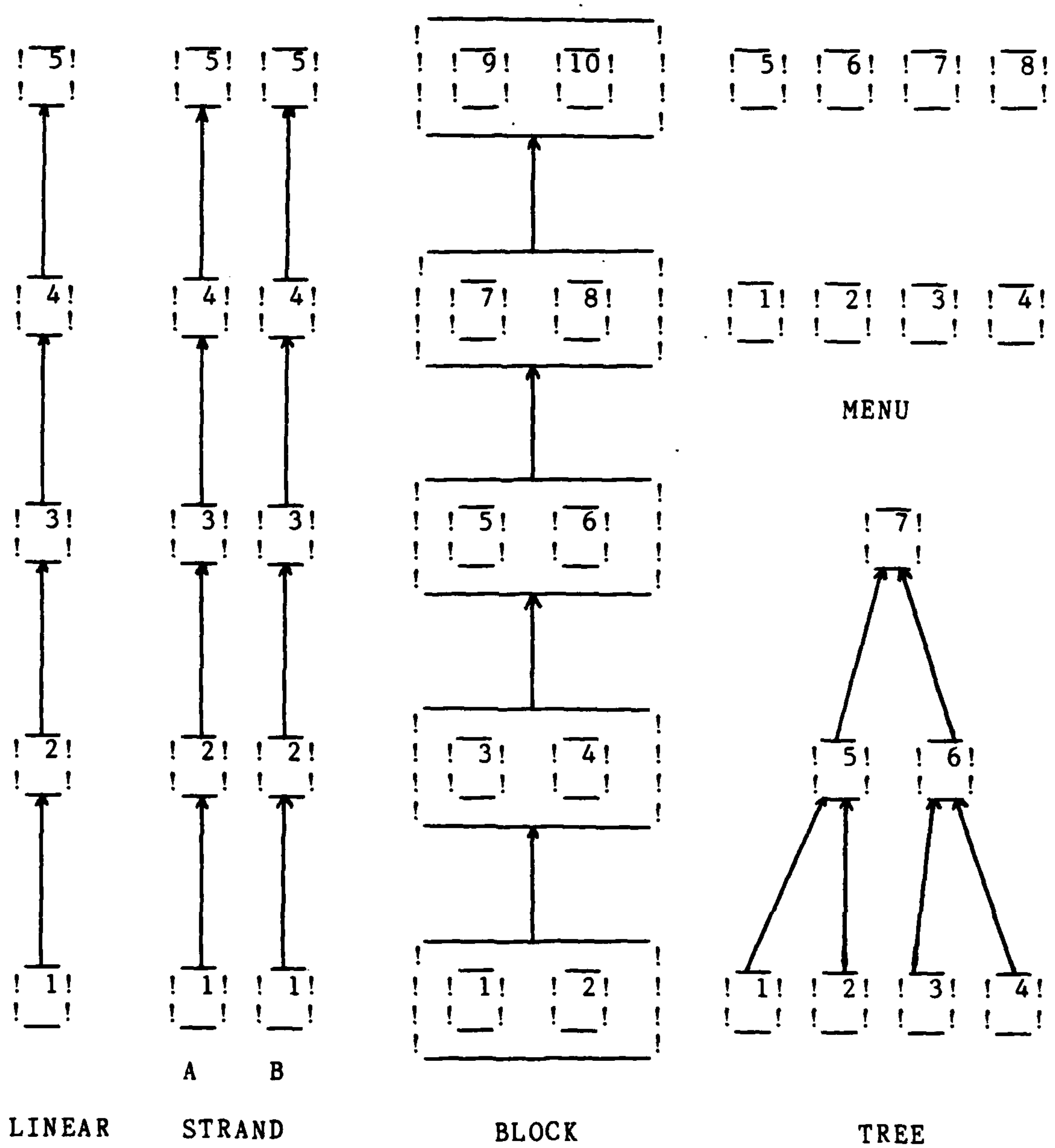


Figure 3.1 CMI Curricular Structures

prerequisites before proceding to a higher level in the tree, and a given student may be at a very high level in one part of the tree and at a low level in another.

The final structure is the menu, in which the total course is divided into modules or units that are unstructured. The student is free to select any module to study, and when he completes it, he is free to select from the "menu" of remaining units.

Each curricular structure of the five outlined successively provides a greater degree of individualization of instruction. The more complex the structure, the more individualization is provided, but the greater the amount of record-keeping necessary to track the student through the curricular plan. Highly fractionalized curricular plans result in larger files in the computer's memory as well as in additional programming to handle the files and monitor students. Thus, the simpler structures tended to predominate in early CMI developments, but in recent years use of the more complex structures, such as the tree and menu, has increased with the reduction of computer hardware costs.

D. INSTRUCTIONAL MODEL

The instructional model is the mechanism used to implement a curricular plan in the instructional setting. It specifies the functional flow of the educational program, the roles of teachers and students, and the educational philosophy serving as its basis.

The instructional model underlying most CMI systems consists of six parts:

1. The goals of learning are specified in terms of observable student behavior.

2. The learner's initial capabilities relevant to the forthcoming instruction are assessed prior to commencing instruction.

3. Educational alternatives adaptive to the initial profile of the student are presented to him. The student selects or is assigned one of these alternatives.

4. Student performance is monitored and continually assessed as the student progresses.

5. Instruction proceeds as a function of the relationship between measures of student performance, available instructional alternatives, and criteria of competence.

6. Data is generated for monitoring and improving the instructional system as instruction proceeds. [Ref. 36]

In essence, this model serves as a basis for not only CMI, but also for CAI and even manually managed programmed instruction. This model relies on the mastery of behavioral objectives built around the unit-of-instruction cycle. This cycle is simply the pretest to determine which objectives in the unit the student has already mastered, instructional procedures for the remaining objectives of the unit, embedded testing, and finally a post-test of all objectives in the unit. When the student achieves a test score above some pre-established mastery level (usually 70-85 percent), then the student is said to have completed a unit-of-instruction cycle [Ref. 37].

As feature number four of mastery learning has indicated, from Chapter III, Section A, the testing to establish mastery levels is termed objectives-referenced, or more popularly known as criterion-referenced testing. It attempts to ascertain an individual's performance with respect to some criterion or performance standard. It contrasts with the more typical testing in education today, called normative-referenced testing, which attempts to ascertain an individual's performance in relation to the performance of other individuals using the same measuring device. [Ref. 38] In other words, normative-referenced testing provides information about the capabilities of one student as compared to the capabilities of the other students, whereas criterion-referenced testing provides precise information on what the student knows and does not know.

Finally, the unit-of-instruction cycle of CMI's instructional model is analogous to a factory production cycle. A completed curricular unit represents the product, and a criterion-referenced test represents the standard of work. Educators then design the instructional model to enable the unit-of-instruction cycle to function as efficiently as possible, thus maximizing production. [Ref.39] Some designers of CMI systems contend that the instructional model places too much emphasis on unit productivity rather than overall learning. This may have some ramifications to the educator's management style. In any case, the model still serves as the basis for all operational CMI systems today.

IV. THE CMI SYSTEM

CMI systems are computer-driven, management information systems specifically designed to support the management process and functions associated with individualized education. The preceding chapter demonstrated how the conceptual foundation for CMI rests on its educational component. This chapter, therefore, explores the actual application of this educational component in terms of the CMI system. The analysis hinges on two aspects: first, the examination of the complement to the educational component - the computer component; and second, the examination of the generic functions of CMI systems.

A. THE COMPUTER COMPONENT

The CMI computer component consists of three primary areas: hardware, system configuration, and software.

1. Hardware

Appendix A illustrates the diversity of the computer systems used in CMI systems today. Generally, the mainframes reflect CMI being a management information system, with a light scientific computing load, and instruction repertoire being I/O, and data manipulation-oriented rather than calculation-oriented. Considerable flexibility also exists for the CMI designer in terms of mass storage. A variety of methods can and have been used, ranging from floppy disks to megabit memories, depending on the curricular structure, the number of programs, and the student flow. Although the hardware certainly plays a key role in CMI, there exists considerable variation in the way this role is fulfilled: microcomputers (a recent advance in CMI), minicomputers, and large-scale mainframes have all been utilized for CMI.

A more detailed illustration of this variation of hardware use in CMI systems is represented by the mechanism for capture of instructionally related data generated during the course of instruction and by the management of instruction. Early CMI systems used specialized forms for data collection, which were then given to key punch operators who entered the data onto cards which served as the computer's input medium. This method has today become obsolete.

Mechanisms used today for data collection include optical mark readers, CRT displays, and keyboard terminals. The primary device currently used in CMI systems is the optical mark reader (optical scanner). Optically read test answer sheets have long been a tradition in education, and this tradition has carried over into CMI. The optical mark reader allows the use of pencil marks on a card or sheet of paper to be used as computer input. A number of these devices exist, ranging from desk-top to high-capacity machines. Generally, most CMI systems incorporate the one sheet-at-a-time desk-top model, as they are inexpensive and can be used by students and placed where the instruction occurs.

The CRT terminal with keyboard can be used as a "dumb" terminal, or a "smart" terminal for cases where instructors perform on-line file maintenance and other administrative functions. This smart terminal can be programmed to facilitate the execution of data-input procedures and reduce the load on the mainframe when large numbers of terminals are used. Both types of CRT terminals can be backed-up by a hard-copy device to print the contents of the screen. [Ref. 40]

The keyboard terminals are useful for generating short, hard-copy reports. Typically, they are paired with optical readers. [Ref. 41]

Irrespective of the type of on-line terminal used for data collection, a terminal interface to the computer is required. Depending on the mainframe design, these terminals are interfaced via the computer's I/O channel capabilities or via a front-end processor to relieve the mainframe CPU of the low-level technical process of communicating with terminals.

One additional mechanism for data collection is a microterminal under development for the U.S. Air Force Advanced Instructional System (AIS). This system interfaces directly with the CMI mainframe, eliminating the optical mark reader and its problems of reliability and maintainability associated with the mechanical aspects of optical mark readers. It also eliminates the use of the optical mark sense forms; although only costing $.03 each, the AIS supports 3000 students, each taking criterion-referenced tests almost every hour. This enables the initial capital investment in hardware, which continues to decrease, to replace the increasing recurring costs of computer form usage. [Ref. 42]

Thus, the hardware aspects of CMI systems are not particularly complex. CMI system designers have been quite conservative with respect to hardware: CMI systems typically remain a considerable distance behind the technological hardware frontier of computer systems in general. Perhaps this conservatism was unintentionally instilled in the CMI designers in those early evolutionary years of educational technology, as advocates of CMI observed the many technological failings experienced by their CAI brethren, and decided then to plant deep roots for CMI and progress slowly but steadily.

2. System Configurations

System configuration refers to the way the various hardware components interact with each other. As expected from the variation of hardware, the range of possible CMI systems configuration is truly vast. There is no one "best" configuration and no specific rules exist for matching alternative CMI systems' configurations to applications. At one end of the spectrum, CMI system configurations are simple, portable, and inexpensive. For example, a 1983 design of a CMI spelling system for an elementary class consists of eight Texas Instruments Speak and Spell units (sold for less than $50 each), connected to a Texas Instruments 99/4 Personal Microcomputer [Ref. 43]. On the other hand, CMI system configurations can be complex and expensive; e.g., the Air Force AIS utilizes a large CDC Cyber computer, fifty interactive terminals, and supports over 3000 students a day in four courses [Ref. 44].

Despite the myriad of CMI systems, each one generally can be categorized as one of three computer hardware configurations [Ref. 45]. Figure 4.1 illustrates the three configurations: centralized, standalone, and distributed.

The centralized configuration utilizes a large central mainframe which allows the sharing of central processing resources and storage capability. Early CMI

P = Peripherals
S = Storage
T = Terminal

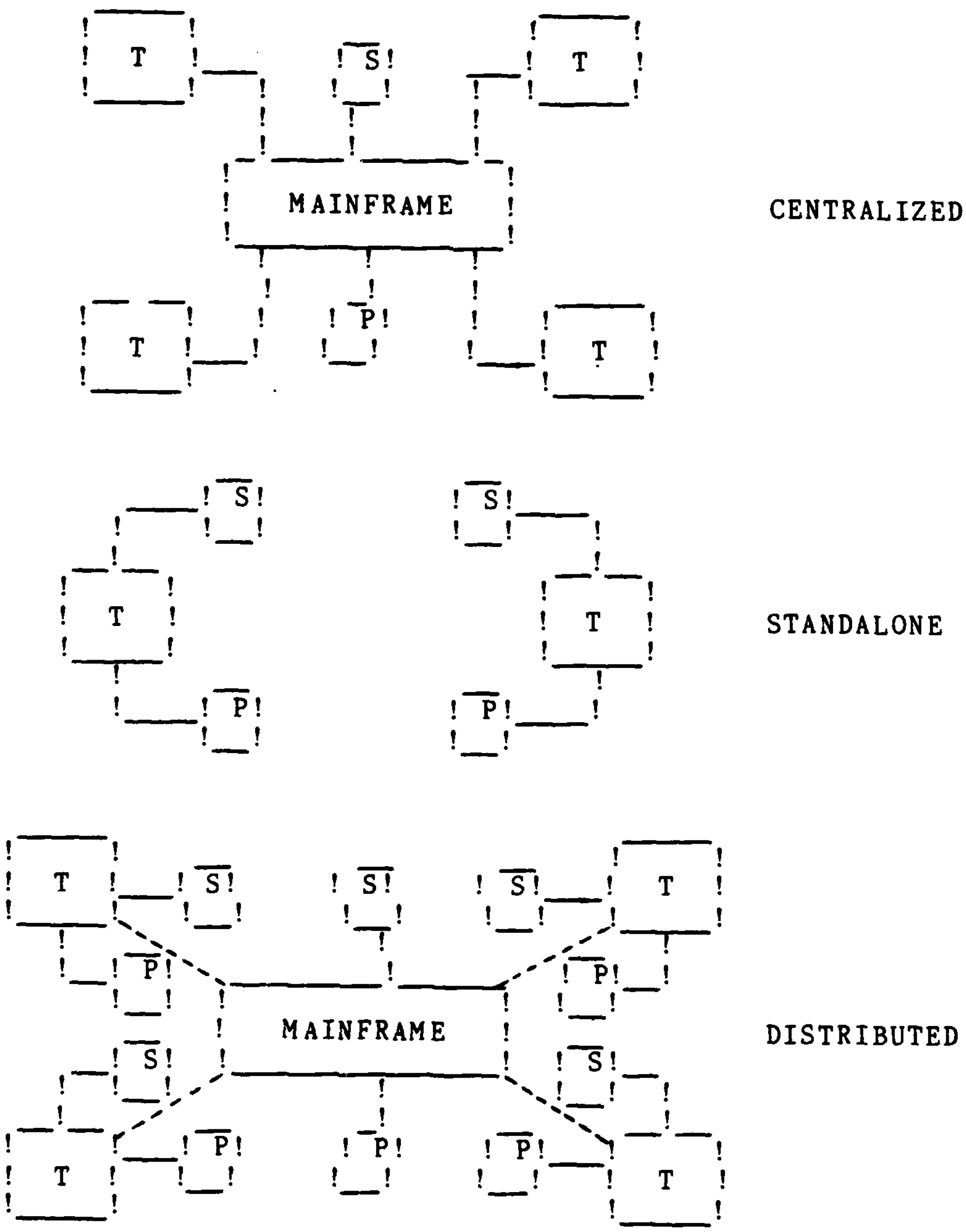


Figure 4.1 CMI System Configurations

systems used thi. configuration predominantly, as educators developed their systems to tap from or "piggyback" onto the capability of their institutions' already existing mainframes, which were used for administrative and/or accounting purposes. These early systems used batch mode, processing their CMI jobs during the night. Many CMI systems continue to utilize batch processing today, although a variation called remote job entry, in which physical transport of input/output to and from the computer is eliminated by telephone connections, has been used more often.

Other CMI systems which utilize the centralized configuration incorporate a time-sharing approach, with terminals tied to the mainframe via a communications network over short distances using coaxial cables, or over longer distances, commonly using telephone lines, or even in one instance using satellite connections [Ref. 46]. With the reduced hardware costs in recent years, more CMI systems have shifted to these interactive terminals. It increases the level of responsiveness of the system: data can be entered as it is created, reports printed upon demand, and in general it places the full capability of the computer component at the disposal of the teacher or student.

The U.S. Army Computerized Training System (CTS) represents an alternative to using one large-scale mainframe but is still considered a centralized configuration. Six minicomputers (PDP-11/35), each functionally specialized, are configured to achieve the capabilities of a larger computer at a much lower cost. The inter-computer coordination is handled by the system controller much in the way an operating system does in a large-scale mainframe. [Ref. 47] This multiple-mini configuration is also employed by TICCIT, but only two computers are used [Ref. 48]. Where the computer configuration is dedicated to CMI, this multiple-mini approach is particularly viable.

With the widespread availability of inexpensive microcomputers, the use of these computers for CMI has increased. But as in the past, CAI has proven to be the first to utilize the new technology, and to do it most extensively. Implementation of CMI in a standalone configuration using microcomputers has been achieved only in combined CAI/CMI systems or in extremely simple systems, such as the Texas Instruments Speak and Spell system mentioned previously.

Standalone configurations are used without the need for a mainframe or a complex communications network. They offer a great deal of flexibility (and portability) since each terminal can be equipped with the specific features needed for each particular application. Some terminals may need color, audio, or video interfaces for CAI tutorials, whereas other terminals may need alphanumeric capabilities for CMI activity. Implemented standalone configurations are not able to take advantage of shared processing or storage capabilities. Thus, the speed of processing is determined by the particular limits of each terminal, and the amount of student data storage possible is determined by the capacity of the disk drives attached to the terminal. Any input/output peripherals needed must also be provided for each terminal. Recent use of the larger capacity disk drives (Winchesters) and local area networks have reduced the limitations of standalone configurations, and an increase in their use is anticipated.

The emergence of distributed configurations is also novel for CMI systems today. Combined CAI/CMI systems, such as PLATO and TICCIT, are presently undergoing modification from a centralized configuration to a distributed one [Ref. 49]. Once again, CMI developers express caution and conservatism, and desire not to be part of leading technology. They cite numerous deficiencies with the distributed configuration, such as increased software complexity, an extensive dependence on communications technology, lack of central control, and lack of standardization. Since so many CMI systems have been developed by educators who shared computer resources with their respective institution, the reluctance of CMI developers to move to the distributed concept is not surprising.

With the large number of military computer-based systems for weapons control, missile systems, command and control, etc., which employ some distributed computing systems, the U.S. Navy has realized the potential for the distributed concept in their training arena, specifically for CMI, and cites the following advantages of the distributed configuration:

- increased reliability and availability,
- increased modularity,
- increased flexibility,
- increased resource sharing,
- increased responsiveness, and
- system expandability in smaller increments.

The Navy has initiated further studies to plan for CMI distributed configurations. It makes the bold prediction that distributed configurations will replace centralized ones by 1995. [Ref. 50]

3. Software

Much of the success of CMI systems can be attributed not to hardware and system configurations but to sound software design. Although CMI designers have not been on the technological forefront of hardware usage, unlike their CAI counterparts, the software reflects their desire to build flexible and adaptable programs which can readily be changed to correspond to changing instructional requirements.

Most CMI systems have their computer programs based upon a modular approach where each module is as self-contained and independent of other modules as possible. Where possible, functions performed by several modules are isolated in a single utility subroutine. And the top-down design approach serves as the basic design technique in CMI software design.

Figure 4.2 depicts the major software components of a generalized CMI system [Ref. 51]. Figure 4.3 shows an alternative high-level block diagram for CMI software [Ref. 52]. This latter figure illustrates the hierarchical, modular nature of CMI software, and will be referenced in the following functional description of each of the major software modules [Ref. 53].

The major module controller or supervisor module, the focal point of the software, serves as the means of communication between the user and the system. It acts as the executive program for the CMI system which obtains control from the computer's operating system. Its capabilities include:

- User log in and authorization.
- System initialization and shutdown.

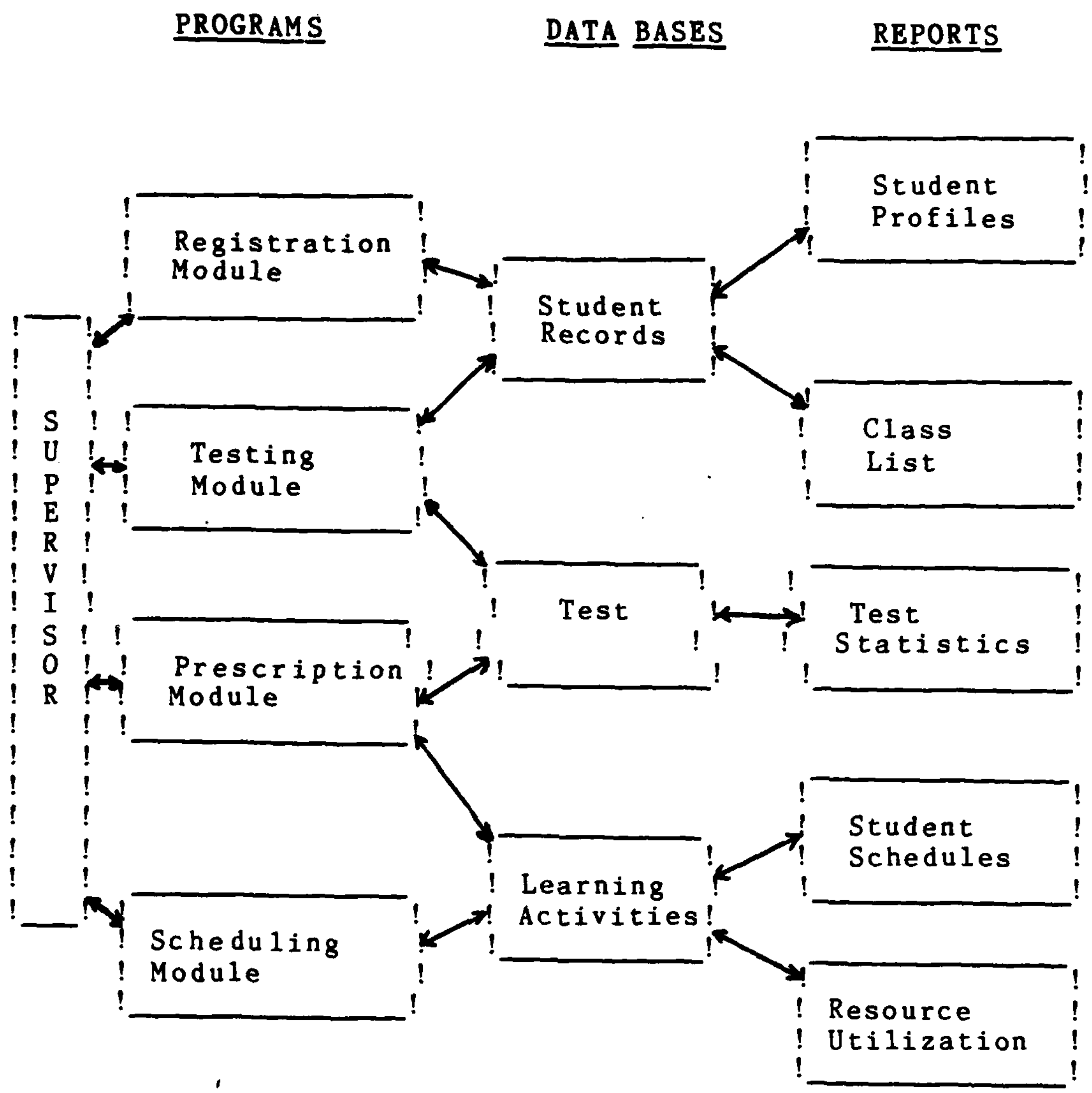


FIGURE 4.2 Software Components of a CMI System

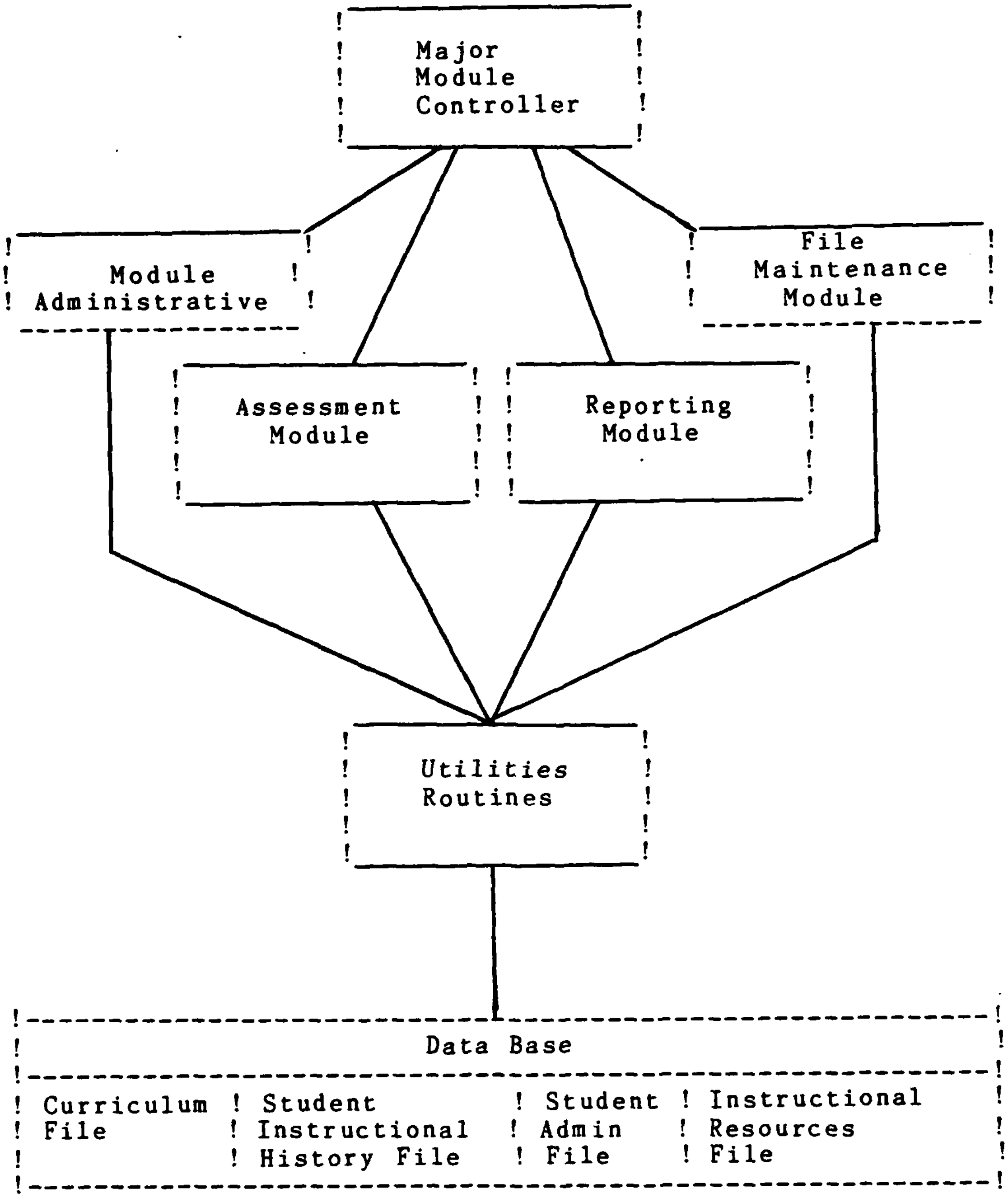


Figure 4.3 CMI Software Structure

- Primary mode selection. User selects function desired from the menu; control is then passed to the appropriate major module.

- Error recovery. Modules which cannot cope with an error situation pass control back for resolution.

The administrative module implements those functions associated with instructionally related administrative procedures, and includes:

- Program of studies. This includes the generation of a predetermined program of study or the creation of a unique program of study for each student.

- Resource allocation. This allocates instructional materials, physical facilities, and personnel.

- Attendance monitoring.

The assessment module processes the various measurement instruments used, and includes:

- Test scoring,

- Diagnosis, and

- Prescription.

This module determines whether or not a unit has been mastered, or to what extent it has been partially achieved. It also provides appropriate prescriptions in the form of next units or remedial activities.

The reporting module provides information on students, the curriculum, and the system in a concise, organized fashion. The user can select a particular type of report, and the report is generated and depending upon the user selected options, displayed at a CRT and/or produced as a hard copy. This module also enables the instructor to collect data on groups of students, on single instructional units, or on groups of units.

The file maintenance module performs those functions needed to create and maintain the data base. It is called upon by the controller module when the user is initializing or updating information. This module also maintains an audit trail of the actions taken against the files.

Finally, the utilities module encompasses the functions that would normally appear in many different modules, the collection of which is represented in subroutine format as follows:

- Data extraction: obtains data elements from their storage arrays.
- Data insertion: inserts data in the proper location in the data base
- Statistical functions.
- Interface routines.

Many of these utility functions can be performed by a data base management system; however, CMI systems have yet to integrate standard data base management systems with their CMI system software.

Although CMI designers may have been successful with their top-down approach and modularity of programs, the lack of standardization of programming languages has impacted on many CMI operations. A report published as early as 1974 indicated that 65 different computer languages or variations of languages were used for CMI [Ref. 54]. Actual CMI computer programs have been written in standard programming languages such as FORTRAN, COBOL, and BASIC, or employ one of the special languages created for CAI usage, such as IBM's COURSEWRITER or PLATO'S TUTOR.

In many early CMI systems, the actual CMI instruction was expressed via the programming language; e.g., the questions to be asked of students were embedded directly in the computer programming. Thus, if a question needed to be changed, that segment of computer program required recoding. The TICCIT system incorporated this method. Today, it is well recognized that well-designed CMI systems place the courseware, or the curricular plans, prescriptions, tests, etc., in the data base, not the software.

A contemporary, high-level CMI programming language has yet to be implemented. A primary developmental effort in this area is being conducted by the Air Force AIS. The language is called Computer Assisted/Managed Instructional Language (CAMIL). Its capability includes the enhancement of instructional software development for both CAI and CMI, and is expected to be more effective and efficient for CMI than any other high level languages. CAMIL, incidently, shows a very high degree of similarity to ADA, and as ADA, it possesses a versatile support environment. [Ref. 55]

B. CMI SYSTEM FUNCTIONS

As alluded to in the attempt of defining Computer-Managed Instruction in Chapter II, there is much disagreement about what constitutes a CMI system. Consequently, it is not only difficult to derive a precise definition of CMI, but it is equally complicated to list a set of functions common to all CMI systems. CMI literature abounds with descriptions of systems, and in all cases the lack of functional commonality forces each author to initially delineate the functions of his particular system prior to any further detailed discussion of his particular system.

In a simplistic viewpoint, the educational and computer component together form CMI. In many situations of CMI evolution, the curricular plan and the instructional model for an individualized course had already existed while the computer component was simply "added on". The computer was viewed as a tool to "unburden the teachers in individualized instruction." [Ref. 56]

Although the computer component plays a key role in CMI, there has been considerable variation in the way in which this role is fulfilled. During the fifteen year CMI life history, CMI system functions have evolved just as the systems themselves.

Therefore, rather than examining the functions of individual CMI systems, this section looks across rather than within the individual systems in order to develop a composite picture of CMI system functions. An attempt is made in this discussion of the system functions to be less specific than the 184 function listing of the AIS system [Ref. 57], but to be more encompassing than a generalized three function listing, such as data collection, data storage, and data processing. The functional descriptions presented herein represent a compilation of the more significant items as specified in the literature of CMI systems and as highlighted by some leading CMI researchers including Baker [Ref. 58], O'Neil [Ref. 59], McCombs and Dobrovolny [Ref. 60], Peters [Ref 61], and the Dutchmen, Leiblum and van Hees [Ref. 62].

1. <u>Testing</u>

Some incentive for CMI development resulted from computer usage to score tests and average grades, as educators have perceived the merit of being freed from clerical chores so that more time could be spent on other aspects of instruction. The mastery learning concept, which requires each student to pass tests one module at a time at a minimum performance level, and the individualized instruction concept, which enables each student to take a test when prepared, both necessitate the administration and scoring of an extremely large number of tests in any large class-size course. The CMI computer can be used in a multitude of ways to select, administer, and score student tests. [Ref. 63]

a. Individualized Test Selection

The computer can assign a particular test form randomly or consider such information as individual student characteristics and the test forms the student has already received. The most complex type of test form selection involves having the computer construct unique test forms for each student by randomly selecting test questions from a computer-stored test-item bank. If both capabilities exist, the computer can assign students to on- or off-line testing, with the assignment based on such considerations as terminal availability or particular student requirements for on-line testing.

b. Item Generation

The item (question) generation capability is useful where large amounts of similar test items are necessary, e.g., arithmetic problems. By creating a skeletal question framework and an algorithm to supply random numbers as parameters, a great number of questions can be generated. Also, rearrangement of multiple choice answers can be accomplished.

c. Scoring of Tests Taken Off-Line

The computer can score multiple-choice or true-false tests taken off-line, and can be programmed to score these tests in a variety of ways. Five possible off-line scoring options can be used as follows:

- Preset criterion. Each answer is scored as right or wrong with a designated percent correct required to pass.

- Correction for guessing. The total score on a test is automatically corrected by a pretest factor for guessing.

- Question weighting. Some test questions can be weighted more than others.

- Scoring based on objectives. In a criterion-referenced test, one or more test items are associated with each instructional objective. To pass a test, the scoring criteria may require that a certain group of objectives be passed or that a specific test question be answered correctly to pass a particular objective.

- Scoring based on performance tests. Although direct performance-based test scoring (e.g., repairing an electronic device) is not possible off-line, the computer can score and provide feedback on performance checklists completed manually by the student. [Ref. 64]

d. On-Line Testing Capabilities

On-Line testing is more expensive and complex, so it is reserved for CAI primarily, and used infrequently by CMI systems. A number of potentially valuable on-line testing capabilities do exist, and with declining costs of micro and minicomputers, adopting interactive testing may become more feasible in the near future:

- Constructed response answers. Student enters a short answer or fill-in-the-blank response on a keyboard.

- Varied presentation orders. Test items, stored in an item bank are randomly chosen and presented to the student.

- Individualized test construction. Students receive different tests depending upon their performance on previous sections of the course or on previous questions on that particular test. [Ref. 65]

2. Feedback

The term feedback has severalcontextual meanings. Engineers speak of "feedback" as it relates to mechanical and electronic systems; psychologists use "feedback" to describe behavioral processes by which animals learn; biologists speak of "feedback" in terms of sensory inputs or monitoring of alpha waves in the brain. The generic function of feedback is the same in all these situations; i.e., to return part of the output back to the input, thereby creating a closed-loop function.

To the educator, feedback is used to describe any of the numerous procedures used "to tell a learner whether his response is right or wrong." [Ref. 66] The use of feedback as a component of the instructional process is virtually universal. It is assumed to be important, since the experts in psychology and education traditionally look at feedback as a necessary component of the learning process. Studies have shown that achievement increases of 10-15 percent can occur with the use of proper feedback mechanisms [Ref. 67].

CMI systems attempt to provide virtually immediate feedback concerning test results in two general forms:

1. Test scores can be provided in terms of number and/or percent correct and can be corrected for guessing.

2. The feedback can be a list of test items not answered correctly. Detailed analysis data would be collected from a number of students and would be used by course developers to improve instructional material or tests.

CMI developers generally share the view that immediate feedback of the correct or incorrect responses facilitates learning, despite some conflicting studies which claim, in recent years, that delay of feedback may actually improve long term retention [Ref. 68]. Because of the lack of evidence in recent studies on the superiority of either delayed or immediate feedback in producing immediate knowledge acquisition or long-term retention, the use of immediate feedback in Navy CMI training is no longer warranted when cost and convenience of administration are more important considerations [Ref. 69].

3. Diagnosis

Diagnosis is the mechanism used by educators to assess the present status of the student in relation to a specific subject matter area, with the purpose of prescribing (assigning) some educational activity to hopefully alter the student's status in a desired way.

The diagnostic procedures of CMI systems are based primarily upon the results of criterion-referenced tests.

They are purely symptomatic in nature: They merely indicate the status of the student relative to mastery or non-mastery of objectives. CMI diagnosis is therefore not causative, as it does not diagnose <u>why</u> the student has failed to master the given objective. This is not a criticism directed at CMI systems, because diagnosis within the field of education in general is at an "embryonic level of development." [Ref. 70] Causative diagnosis remains a fairly primitive state of the art.

Thus, the actual diagnosis methods are quite simple and restricted. The computer simply talies the incorrect test answers, correlates the result to a specific objective, and then assigns the student remedial work if necessary. Some CMI systems do not produce an automated diagnosis; instead, they generate reports which contain the data used by the teacher who then judgmentally decides whether remediation is necessary or not.

4. Prescription

Prescription is the result of diagnosis. Even more than that, prescription is the complement of diagnosis: Without a diagnosis an effective prescription could not occur, and without a prescription a diagnosis would serve no purpose.

The prescription function refers to the decision-making process whereby individual students are assigned to a wide variety of course activities including different remediation tasks, course alternatives, and counseling. The prescription function implements two types of prescriptions: forward and remedial. When the student successfully completes a module or unit, he receives a forward prescription which assigns him further work based upon the intersection of the student's instructional history and curricular plan. The remedial prescription represents the means of assisting the student in eliminating a performance deficiency. It can simply be a restudy of the material, or an assignment of some other educational activity using some other resource.

a. Precourse Remediation

Before students who have been identified as having deficiencies to certain skills commence a CMI course, they are assigned to specific remediation activities. The system can prescribe the most appropriate activities to individual students based on their unique deficiencies; e.g., students can be assigned to special exercises designed to improve weak reading or mathematical skills, or even more general skills such as test-taking procedures.

b. Within-Course Prescription

This consists of four dimensions:

- Assignment to alternative course versions. For example, students going on to advanced training in electronics may be assigned to a different version of a basic electronics course than students who will receive no further electronics training.

- Assignment to alternative lesson formats. For example, the system can make individualized assignments within a version of a course such as printed vice audio-visual presentation of the same material.

- Assignment to alternative remediation activities. Based on course performance, the system can assign each student to a particular type of remediation activity.

- Student self-prescription. In most CMI systems, either the teacher determines the individual student assignments by using computer generated diagnostic information, or the system itself provides an assignment to each student directly. [Ref 71]

The complemetary functions of diagnosis and prescription provide extensive opportunities for individualizing instruction. Yet, as mentioned for diagnosis, the prescription function has not progressed to a highly sophisticated tool. Although the prescriptive function may be performed automatically by the computer, it consists primarily of one-to-one relations between missed objectives and specific remediation activities. Prescriptions tend to not be fancy. Indeed, increasing the level of sophistication of both diagnosis and prescription is an effort of educational research, with CMI simply involved as the vehicle for accomplishing this goal.

5. <u>Student Progress Management</u>

In individualized instruction, such as CMI, the "self-paced" aspect becomes an immediate and direct concern for the educator and administrator of the course. Although students may be given some latitude in determining their rate of progress, some managerial control of their self-pacing is obviously necessary. Some students may procrastinate. In courses with a limited number of quotas, prediction of student completion time is important to preclude the formation of pools or back log. And in courses where student progress has an immediate economic consequence, such as military CMI where students are paid during training, control of the rate of progress can reduce training costs. Some of the common types of student progress controls include:

a. Progress Forecasting

Completion times may be predicted for each student registered in the CMI course, typically based on a number of variables such as years of education, age, aptitude test scores, etc. These variables are combined statistically to yield estimated completion times. Some subsets of this function include (1) lesson completion estimates used to schedule the instructional resources, (2) course completion estimates used to plan for incoming students, (3) initial versus revised predictions used to revise predictions of student completion dynamically, and (4) identification of problem students.

b. Feedback and Motivation

This is used to encourage students to maintain adequate progress. The system can provide periodic status reports, either daily or following the scoring of each test.

The report format varies substantially from course to course; it can be printed in alphanumeric form or presented as a chart which graphically portrays the student's progress in absolute or relative terms.

Many CMI courses also employ rewards and punishments as a motivating force. Incentives include rewards such as letters of commendation, extra time excused from the classroom, and points for desirable performance that can later be exchanged for some activities. Punishments include letters of censure, assignment of additional study time, or loss of points. The computer identifies positive and negative performance by individual students. The teacher can then decide on the particular reward or punishment, or the computer can perform this function by scheduling and presenting the various incentives according to prespecified performance criteria for the class.

6. Flexible Scheduling

In individualized instruction, the scheduling function assumes prime importance. To operate with maximum efficiency, the student and teacher activities, and instructional materials and CMI resources, must all be organized and coordinated in an optimal manner. Some of the common funtions in the scheduling arena include the following.

a. Scheduling Student Entries

The CMI computer can accurately estimate starting dates for new course enrollees by matching individuals awaiting course registration with information concerning current course enrollments and estimated completion dates. This is particularly useful in courses where students can begin a course at any time, depending on the availability of space; e.g., military training courses.

b. Scheduling Student-Teacher Interactions

The system can schedule meetings between the teacher and individual or groups of students for a variety of purposes, such as (1) guidance and counseling, (2) special performance evaluations, (3) small group discussions, and (4) individual instruction on a particular training device.

c. Scheduling of Instructional Resources

Whereas the previous aspects of scheduling get the right students to the correct places, this type of scheduling involves the positioning of the proper materials, facilities, and staff to meet the student schedules; i.e., a resource allocation. The system can assign the students directly to an instructional resource, such as textbooks, interactive terminal, group discussions, etc. Or the student can select the resource from the available options as provided to him by the computer. The system monitors the usage of each resource. For example, if three students have been assigned readings from the same book and there are only three such books, the system recognizes this and would not direct a fourth student to that same book. [Ref 72]

d. Out-Processing Activities

As the student approaches graduation from the course, the system can schedule a variety of post-course activities, such as arranging time and place for the final examination, arranging for transfer of student records, and generating diplomas, order, or other necessary documents.

7. <u>Reporting</u>

This represents the final key function of CMI systems. Many CMI implementors contend that this is the most crucial of all functions. Indeed, much of the power of CMI systems stems from the ability to exploit the data base, and maintain extensive records and generate the reports needed for management purposes.

Record keeping and reporting served as one of the earliest and most extensively used functions of CMI in its initial development. This function distinguished the new technology of CMI from simple test scoring devices. Because of this early usage, many different types of reports have evolved and a great variation of these has been employed today in CMI systems. Two categories can be conveniently assigned according to whether the information is primarily intended for course instructors or course/school administrators.

a. Reports for Teachers

To operate an effective individualized curriculum, the teacher must have easy access to information about each student and the class as a whole. CMI provides the teacher with individual progress reports which outlines individual performance data such as (1) number of modules completed, (2) number and scores of tests, (3) predicted course rate, (4) amount of time spent in remediation, and (5) the amount of positive and negative incentive credits earned by each student with the corresponding reward or punishment given.

The second teacher report, called student history reports, can be used for guidance and counseling, and frequently, at least in the military setting, follow the student to subsequent courses in hard copy. Student history reports commonly include (1) biographical data, (2) the modules and curriculum completed, and (3) many of the measures collected in the individual progress report, but listed here in aggregate format.

The final report for teachers is the class or group report, which can be printed periodically, as most reports (e.g., daily or weekly). This report enables the teacher to evaluate the educational status of individual students or groups of students from a single report. Flags may be used to readily designate those students with low progress rates or with many failed tests.

b. Reports for Administrators

These reports again may be generated regularly or periodically as desired, and provide (1) the number and qualification of students awaiting training, (2) the number of students currently enrolled in the various courses of the school, (3) the distribution of completion times for individual lessons and courses, (4) the use of various instructional resources, and (5) the teacher performance as indexed by the number of students and amount of time in various instructional activities.

V. SOME REPRESENTATIVE CMI SYSTEMS

Incorporation of all of the functions as described in the preceding chapter is not accomplished by every CMI system. Each system distinguishes itself from another CMI system by its unique set of functions. Also, the existing computer and peripheral resources available, funding, and instructional needs as based upon course content and type of student (e.g., elementary, college, vocational) all greatly affect the type of CMI system an organization will employ. And the available expertise, such as programmers and systems analysts, affects the type of capabilities that will be built into the CMI systems. All these considerations contribute to the development of numerous and diverse CMI systems.

This chapter ties together the educational and computer component, as discussed in the two preceding chapters, to examine the result of their coalescence and interaction: the CMI system. The two systems selected demonstrate the diverse nature of CMI applications, yet reflect the common conceptual basis.

A. MICA

Managed Instruction with Computer Assistance (MICA) is a small-scale CMI system which supports a single mathematics course for use by fourth and fifth grade students and teachers in a single school, the Sherman Elementary School in Madison, Wisconsin.

In 1969 the staff at Sherman School developed the curricular plan and instructional model in order to individualize their mathematics program. The perpetual problem of being overwhelmed by instructional paper work resulting from this individualized program for 150 students led to the recognition of the need for computer support. So, in 1971 a three year cooperative effort was launched between Sherman School and the University of Wisconsin, and in 1974 MICA became operational. [Ref. 73]

Since the system does not actually score the student tests, no optical readers are needed. Upon completion of a test, the teacher grades it and then enters the data via an interactive display unit, a Hazeltine 2000 CRT and keyboard. The display unit is connected via modem and telephone line to a UNIVAC 1100 series time-sharing computer system at the University of Wisconsin. A printer connected to the display unit outputs reports and also the generated tests.

The software was conceptualized, written, and implemented by a team of primarily graduate students from the University, as a two-semester computer science project. The structure consists of a series of cascaded drivers, where each module contains a driver to control the interactions among its submodules, and the major modules themselves are coordinated by one master controller module (similar to Figure 3.1). The program consists of approximately 8000 lines of code (6000 lines at first implementation) written in FORTRAN WATFIV. Its design conformed to a top-down, modularized approach, and includes full documentation easing future software maintenance. [Ref. 74]

Today, the system manages a combined fourth and fifth grade mathematics curriculum for approximately 165 students. During the mathematics period, all the students converge into one area of the building, where they then split into various "CMI" rooms depending upon their unit of instruction. Each of the rooms contains at least one teacher who performs a specialized function; use of teachers in such an instructional model is relatively unusual among CMI applications, as students gain considerable teacher contact and individual attention in these study, lecture, and testing rooms.

The subject matter is divided into 63 units of instruction arranged in a linear curriculum structure, giving the students no option to their study material. Reviews appear at interval of five units. Each unit has an associated pre- and post-test. Locally prepared study guides in either printed or audio-tape format introduce a unit to the student, with a variety of textbooks and other locally developed printed materials employed by the student in the actual study of the unit objectives. The student does not have a great variety of instructional materials to select from, nor does he have the latitude to select the desired material or to study when he desires, contrary to the pure concept of individualized instruction.

The system generates several specialized reports for teachers to aid in the management process. The Student History Report contains a comprehensive record of a student's instructional history, even including the identification number of unit objectives failed on tests. A Group Report lists students by homeroom, showing their currently assigned unit with dates of completed tests, and is used by the homeroom teacher to monitor their student's progress. A Contact Report contains the names of students having no contact with the computer since a given date, serving as a flag to locate students who get "lost" in the system or identify absent students. All the reports can be run regularly or periodically as needed. It should be further noted that the homeroom teachers have no grade books for mathematics as all information is stored by the computer and printed in report format. Thus, the reports are used to monitor student progress, detect patterns of achievement, prepare report cards, and to evaluate the curriculum. [Ref. 75]

Major lessons learned from the MICA System are primarily educationally related. Locally developed individualized instructional material is too expensive and time-consuming. Many developing CMI systems become snarled in this process, giving CMI a bitter taste to many educators. Today, a variety of commercially prepared instructional materials is available, which has been designed by task analysis or by the Instructional Systems Development (ISD) process.

The actual management of the CMI curriculum serves as another lesson learned. The key to successful operation does not rest on the technical aspects nearly as much as the ability of the educator to effectively manage the system. When the educator does not understand the tasks to be performed, the instructional material available, the CMI resources, or his role in CMI, the chances of operating an effective and efficient system will be reduced. This latter aspect of educator's role in CMI will be discussed in the next chapter.

B. NAVY CMI

The U.S. Navy operates the world's largest and most experienced CMI system. Based in Millington, Tennessee, it currently trains 15,000 students annually, at five separate geographical locations in 24 different technical training courses. There is nothing particularly unique about the Navy CMI System; its distinctiveness lies in its maturity, as it has been tested, tuned, retested, and fine-tuned until it operates at a high level of efficiency. [Ref. 76]

The development of the Navy's CMI system can be traced directly to work started in 1967 by the Chief of Naval Air Technical Training (CNATECHTRA) in Millington. G. Douglas Mayo of that activity proposed that instruction in the Navy's technical training courses be revised from conventional to individualized formats. The high development costs of CAI could not be justified by the Navy, so Mayo suggested that the computer be used to manage not deliver the instruction. In 1968 Mayo's CMI project was approved, and his command, together with the Naval Personnel and Training Research Laboratory in San Diego, formally entered into an advanced development project to develop a CMI system. [Ref. 77]

By 1970 a prototype had been designed. During 1972, the first course - Aviation Fundamentals - was officially conducted with the prototype system. In mid-1973 the Navy CMI system became operational in two courses at the Naval Air Technical Training Center in Millington. A wide mix of military and civilian researchers - technical experts in computer technology and instructional design specialists in education - contributed to the system design, resulting in a successful development of an operational system within five years. In 1974 the Chief of Naval Education and Training (CNET) adopted CMI as a formal component of the Navy training system [Ref. 78], and in that year the first Navy definition of CMI appeared in OPNAV INSTRUCTION 1500.39:

> ...a system in which a computer is used to route a trainee through a series of instructional materials, presented by various media, so as to be best suited to his particular needs and abilities. [Ref. 79]

In its eleven year operational history, the Navy CMI System has utilized two different central hardware systems. Initial development and application of the system was accomplished using a Xerox Corporation SIGMA 9 system, with the central computer hardware located at Memphis State University. The Navy shared this computer system with that University.

In 1976, the Navy procured a Honeywell Series 60 Level 66 System. Redundancy was built into the system for reliability purposes, as it was configured so that no central hardware device would, when down, render the system incapable for a period of longer than ten minutes [Ref. 80]. The Honeywell computer is not, however, used solely for CMI. The system supports the administrative functions of personnel support, supply and logistics, and recruit training administration. No degradation of CMI performance has yet occurred.

The Honeywell System remains as today's Navy CMI System. Through a networking system using dedicated 9600 baud lines, remote sites at the five locations, the furthest being Orlando, Florida and San Diego, California, link CMI data to the Honeywell dual processors in Millington. At each site a communications interface to a Honeywell Level 6 concentrator is established via modems. These concentrators are in essence communications computers which multiplex inputs from the learning center for transmission to the central computer in Millington. The concentrators also route return data to the proper receiving station. [Ref. 81] In event of central processor failures, or failure of the communications lines to the central site, the concentrator is capable of receiving from the learning centers without interruption or delay. Also, dual concentrators are connected via switching units which allow learning centers to be switched to another concentrator in case of a concentrator failure.

This network arrangement between learning centers and the concentrator is repeated in concept at the Millington host computer site. Here, a front-end communications processor multiplexes inputs from many remote site locations. This front-end processor acts as a temporary buffer and switch directing incoming transactions to buffer locations in main processor memory, thus providing temporary transaction data storage while awaiting central processor service. When service is completed, the transaction response information is routed to the proper output communications channel via the front-end processor. In the event of central processor failure, the front end processor's standalone operating system protects against system downtime by continuing to perform many tasks. Automatic restart and recovery features guard against lost information.

In addition to this hardware configuration, another aspect of Navy CMI which provides reliability is the highly modularized software. The systems approach to instructional development was used to provide a set of prioritized skills derived from task analysis; these skills were translated into learning objectives, then into learning modules or units with accompanying self-paced learning materials and performance measures; and, the learning modules were then automated through CMI. [Ref. 83] The modules closely approximate the functional descriptions of software modules for a generic CMI system, as discussed in Chapter IV: some of these features of the Navy package include extensive test, evaluation, and record-keeping capabilities; the option of presenting comments and detailed remedial material; the generation of individual reports; and, the capability of maintaining comprehensive history files for periodic analysis. The software, incidently, is written in COBOL.

Each of the Navy technical schools incorporating CMI have one or more learning centers, a centralized site of one or more large rooms for the conduct of all CMI-related activity. Although the physical layout of the learning centers varies from school to school, the same instructional components are present in all centers, and include:

- Clusters of individual study carrels,
- Equipment area for practicing and experimenting,
- Center for instructional material distribution,
- OPSCAN Model 17 optical mark readers,
- GE Terminet Model 1200 teletypewriter printer, and
- Test area.

To accomodate large numbers of students, some schools may operate two or even three consecutive shifts of trainees a day. The total training day is eight hours, with six hours typically spent in CMI instruction and two hours spent in military instruction. In keeping with the spirit of individualized instruction, students may begin the CMI course at any time. Students work at self-determined paces (as controlled by computer and instructor) and can take breaks at their own discretion.

The curricular plan is organized in the form of modules which encapsulate specific subject matter content. Of the five different curricular structures currently employed in CMI, the Navy system incorporates the block structure to only a limited extent, relying instead on the simpler linear structure, in which the total curriculum is arranged in a module to module sequence. (Refer to Figure 3.1)

Beginning the course, the student receives the first module via an initial learning guide which contains the study assignments. He interacts with the curriculum materials by selecting and studying the various pieces of equipment (generally electronic) and instruction media of textual material or audio-visual displays. Students take a progress check test, usually self-scored, to determine whether they have mastered the lesson materials before they take the module post-test. Each module generally takes two to three hours to complete. The student may seek assistance at any time from the learning center instructor. Generally, the student/teacher ratio is 30:1. [Ref. 84]

When the student feels that all objectives of the module have been mastered, he takes the module test in the designated learning center test area. The test consists of up to 50 five-alternative multiple-choice items. At least three forms of each test are available and are randomly assigned. Students enter their answers onto machine-readable answer sheets, which are then inserted into the optical scanner. Responses are processed by the scanner and transmitted on the telephone line to the central computer at Millington. Within 30-60 seconds, the computer identifies the student and the test, scores the test, stores responses in the student history file, determines the next assignment, and transmits test results and the next assignment back to the student. The printer issues a learning guide which indicates missed questions, lists lessons or objectives needing additional study, and informs the student of remediation tests to be completed after such study. Only when the student has mastered all objectives will the next module be assigned. [Ref. 85]

One of the primary uses of the accumulated data on each student is to facilitate the instructional progress of the students. This is accomplished through a Student Progress Report (SPR), provided daily to the instructor. The SPR is the only report of significance. It lists the daily status of all the students in one learning center who are under the instructional control of a particular instructor. It includes:

- Student name and identification number,
- Assigned module,
- Actual module student working on,
- Actual hours spent in that module,
- Predicted hours to be spent in that module, and
- Flags; e.g., student beginning next assignment [Ref.86].

The predicted number of hours for a module is determined using pre-training aptitude test scores, the number of years of civilian education, student's actual age, school records, and other variables. The instructor monitors how the actual instructional progress of each student compares with his predicted progress. Ideally, this actual versus predicted student progress information enables the instructor to take the corrective action needed to assure satisfactory student progress. Thus although self-pacing occurs through the instructional materials, it is expected that the student will maintain a study rate which results in course completion within the predicted time, and that the instructor will assist the student in maintaining a minimum predicted rate of progress. These instruction progress expectations minimize training time and facilitate timely assignment of school graduates to follow-on schools or fleet billets. [Ref. 87]

C. POST-SCRIPT

Since all CMI systems share a common conceptual basis, some characteristics do typify CMI systems:

1. The actual learning medium is normally traditional textbooks. Most systems have not incorporated the variety of instructional materials which accompanies the theory of individualized instruction.

2. The computer tests the student progress at frequent checkpoints and does not allow the student to continue the program if test results are unsatisfactory, in keeping with the mastery learning concept.

3. After failing a fixed number of retests, the computer will direct the student to academic counseling. The student may retake failed progress tests.

4. The computer selects specific questions for a test from a relatively large test question pool.

5. CMI systems employ objective-type questions, such as multiple-choice and true-false. Matching and fill-in-the-blank questions are rare.

6. Direct interface with the computer for the student is limited; optical reading systems predominate.

7. CMI systems generally use a large-scale computer that serves as the primary administrative computer of an institution. Computer systems dedicated solely to CMI are rare.

However, beyond these characteristics and some other minor ones, and the notion that the availability of a computer is the sole prerequisite to CMI implementation, a CMI system tends to possess its own uniqueness im many areas, such as subjects or curricula supported, extent of system operation, actual functions employed, system configuration, design intentions, etc. This uniqueness of each system strengthens the viability of CMI, and augments its potential for making an impact upon all levels of education.

VI. KEY STUDENT-EDUCATOR ISSUES OF CMI IMPLEMENTATION

The success or failure of system design and development generally first becomes obvious during the implementation phase of a CMI project. If the design and development activities have been performed well, CMI project implementation should theoretically progress smoothly. At least, many CMI designers have believed this.

Unfortunately, a poor job of implementation can ruin a project despite successful design and development, and despite large investments of time, effort, or money. Successful implementation of any kind of new technology, not just CMI, is fraught with potential problems and "opportunities" to make mistakes, which can lead to an operable system much less effective than envisioned, or even failure or disaster. Successful projects do not just happen, but result from extensive planning, coordination, and overall careful management of the implementation process.

In particular, successful implementation of a new teaching method such as Computer-Managed Instruction is a complex and difficult issue. A multitude of factors and considerations accompany CMI implementation, some common to many kinds of new technology implementation, but others unique to CMI (and in some cases to its counterpart, CAI, also). The literature is replete with checklists and guidelines in this area. One author lists twelve factors affecting implementation [Ref. 88]; another includes ten principles to guide implementation [Ref. 89]. One of the more simple, consolidated lists includes six factors underlying successful projects:

1. User involvement,
2. Acknowledgement of the training need,
3. Availability of necessary resources,
4. Readiness of technology,
5. Explicit controls over project resources, and
6. Unambigious understanding of purpose and nature of the project [Ref. 90].

Of all the factors affecting the success of CMI implementation and system operation, the first factor of user involvement is probably the most important [Ref. 91]. User involvement involves sharing varied degrees of control, commitment, and coordination among all participants. Each participant must have some degree of "pride of ownership" of at least part of the system [Ref. 92]. Indeed, it is clear that computer systems in general will more likely be accepted and prove successful if the actual users participate in its design, development, and implementation.

Figure 6.1 exemplifies this: It shows a comparison of different kinds of user involvement in the actual implementation of the same CMI system at two different sites [Ref. 93]. After one year of operation, the system at Site 1 was removed but that at Site 2 remained. The lack of user involvement at Site 1 is evident. On-the-job performance by graduates proved essentially identical at both sites, yet only Site 2 succeeded.

Other CMI researchers contend that the second factor - acknowledgement of the training need - represents an equally critical issue for CMI implementation. The premise of many educators and sociologists maintains that "people resources are paramount". [Ref. 94] In fact, problems experienced with these "people resources", such as lack of support or motivation, poor attitudes, and unfulfilled expectations, have proven to be one of the greatest single handicaps to CMI implementation [Ref. 95]. Proper training, directed at all users of the CMI system, teachers and students alike, represents a mechanism to alleviate these people problems.

Both factors - user involvement and training - complement one another. Both are definitely key ingredients to successful implementation of any system, not just CMI. But, what are the unique obstacles of

	SITE 1	SITE 2
PRIMARY CONTACT	Head of Site	Head of Training
PERCEPTION	Experimental System	Operational System
PLANNING	Involvement only of high level personnel in planning. Instructional design delivered in system.	Involvement of on-site personnel (supervisor and worker) in planning of the implementation. Solicited instructional design suggestions from on-site personnel.
PREPARATION	Developer responsible for design and set-up of training center (on-site personnel provided the support). On-site personnel were inadequately trained prior to system delivery.	On-site personnel responsible for design and set-up of learning center (developer served advisory role). On-site personnel went to developer's site to familiarize themselves with the system prior to shipment.
ADMINISTRATION	Developers retained control of system. Developers provided all maintenance of the system. System management remained the developer's job. Computer-produced student management reports did not meet on-site needs.	On-site personnel ran the system. Site provided first echelon maintenance. System management was part of regular duties Computer-produced student management reports replaced hand-done reports.

Figure 6.1 User Involvement

implementation for CMI systems? And how are they dealt with?

Again, lists abound. One CMI implementor even lists as many as thirteen obstacles which specifically apply to CMI implementation as depicted in Figure 6.2 [Ref. 96]. Another author more succinctly lists five obstacles, as depicted in Figure 6.3 [Ref. 97].

Two obstacles in particular which pervade the literature include issues germane to the CMI student and to the CMI teacher. Therefore, this chapter focuses on these two sets of issues. In keeping with today's emphasis on user involvement and meaningful training/ orientation for users, these two key ingredients to implementation in general serve as the underlying theme for the CMI student-educator issues as discussed in this chapter.

A. THE CMI STUDENT

The concept of attitude assumes such importance because it is prevalently believed that attitudes predispose the possessor toward actions [Ref. 98]. This is particularly valid for the individualized instruction curriculum in which the student becomes an active learner. Examination of this and the preparation of the student

1. Lack of specific needs assessment.

2. Lack of understanding of student and educator attitudes.

3. Educator autonomy.

4. Educator resistance to unproven effectiveness of new instructional methods.

5. Lack of concern for the process of instruction.

6. Failure to follow the most cost effective route to instructional development.

7. Lack of concern for faculty development.

8. Inability of instructional development personnel to communicate effectively and credibly with educators.

9. Lack of experimentalism.

10. Lack of concern for evaluation.

11. Training is not effective.

12. Training does not meet individual needs.

13. Training is not flexible.

Figure 6.2 Obstacles to CMI Implementation

1. Minimal personnel development or training aimed at increasing knowledge and skills about CMI.

2. Technology not properly used.

3. Low level of student interaction.

4. Technology represents a threat to educators.

5. Training does not meet needs.

Figure 6.3 CMI Implementation Barriers

for CMI, from a theoretical and pragmatic aspect, represent the two focal points of this section.

1. Student Attitudes

Educational studies over the past several decades have attempted to associate learner attitude with the amount of success attained in academic pursuits [Ref. 99]. A 1979 study indicated that attitude, even more than aptitude, plays a major role in the student's achievement level in the mastery learning environment of CMI or CAI [Ref. 100]. An additional study of CMI demonstrated that students with positive attitudes achieved the largest gains in learning, whereas students with negative attitudes demonstrated less favorable achievement, and tended to cause more problems in the operation of the course [Ref. 101].

The variables which generate these positive and negative student attitudes toward CMI consist of two categories: (1) system variables, which deal with the hardware and software aspects of the CMI-student interface, and (2) individual difference variables, which deal with student trait and personality characteristics. System variables, when positive, make the CMI system seem fairer, clearer, likeable, and inspire confidence; when negative, they produce complaints of inadequate access, poor feedback, excessive downtime, slow or erratic response time, etc. Individual difference variables possess a base of literature of their own; when positive, they develop an appreciation and understanding of computer capability, but when negative, develop complaints of ineffective education, increase anxiety, and reduced confidence. [Ref. 102].

Identification and verification of a negative student attitude is imperative, since attitudes can adversely affect (1) the way in which students approach their tasks, (2) the competencies they build, and (3) the rate at which they complete the CMI instructional process [Ref. 103]. These three aspects, in turn, can be an impediment to successful implementation and operation of the CMI curriculum.

While accurate assessments of student attitudes are not particularly difficult to accomplish (teacher observations and questionnaires generally suffice), the common approach in CMI is simply to apply motivational tools to hopefully alter the individual difference variables and elicit that positive attitude from all students. Two of the most frequently used techniques in CMI include:

1. Providing the students with progress records: The Navy has found that these "incentive charts" increase motivation, promote positive attitudes, and reduce training time [Ref. 104].

2. Introducing an explicit competitive element into the CMI process: Since CMI testing is competency (mastery) based, competition does not compromise quality of instruction, but increases motivation and promotes positive attitudes [Ref. 105].

A mechanism to control the system variables has been accomplished by the Navy CMI System. Its redundancy features, as discussed in Chapter V, have been designed deliberately because it is such a large-scale centralized system and system reliability is critical. This is in recognition primarily for student throughput concerns, but also serves an ancillary purpose of maintaining positive student attitudes, as slow response time or excessive downtime can induce negative attitudes. When dealing with 10,000 students and a tightly controlled training budget, all aspects of the CMI program become significant, including this seemingly inconsequential aspect of student attitudes.

2. Preparing the CMI Student

Although considerable effort has been devoted to improving the hardware, software, and instructional materials which support CMI systems, the problem of preparing students to utilize their skills effectively and efficiently within this system has received less attention. Until individualized instruction becomes commonplace in schools, students will find CMI to be a novel learning environment [Ref. 106]. Few of these students will possess the knowledge or skills which enable them to use the capabilities of CMI effectively. Thus, if the CMI systems being designed and built are to be most effective and efficient, a definite requirement exists for orienting students to novel system capabilities and equipping them with minimum skills to capitalize on these capabilities.

A number of studies support this position and have suggested the need to train students to appropriate strategies for adapting to and profiting from the new learning experience of CMI [Ref. 107]. A compilation of these studies suggests three areas which require consideration for effectively preparing the CMI student and ultimately improving the implementation position of the CMI system:

1. Orienting students to novel learning environments.
2. Providing students with skills for managing their time in the self-paced environment.
3. Providing students with specific study skills required in individualized instruction [Ref. 108].

Figure 6.4 illustrates the various factors involved in just this first consideration of orienting students to novel learning environments [Ref. 109]. Incidently, one investigation has noted that systematic orientation to CMI seems to sensitize the student for CMI methods and precludes development of potential alienation and the formation of negative attitudes [Ref. 110].

Although the literature is replete with suggestions for the type of information students should be given in an orientation to the novel learning environment of CMI, there is conspicuous absence of actual working mechanisms used

THE PHYSICAL DIMENSION

- variety of multi-media materials
- learning centers; individual student carrels
- resource centers for obtaining learning materials
- testing rooms with reader/printer equipment and/or interactive terminals
- mark-sense answer sheets

THE LEARNING PROCESS DIMENSION

- assignment of a variety of instructional materials on basis of student's performance
- availability of organizers such as objectives, embedded tests, and reviews
- frequent criterion-referenced testing
- individualized pacing
- computer scheduling of learning activities and equipment
- equipment failures which interrupt learning

THE SOCIAL DIMENSION

- less opportunity to discuss course content with peers
- less opportunity to assess one's own performance relative to others
- more emphasis on self-responsibility
- objective (computer) performance evaluations rather than subjective (teacher) evaluations
- individual interactions with teachers

Figure 6.4 Student Orientation to Novel Learning Environments

within CMI systems which implement these suggestions, with one exception. The U.S. Air Force Advanced Instructional System (AIS) has in recent years become the leader in the development of formalized student training: AIS researchers have developed individual training lessons in modularized format for not only orienting students to CMI, but also for providing students with the aspects of item 2 and 3 above, namely time management skills and specific study skills. [Ref. 111]

The modules designed are sufficiently general so that they can be used in other military CMI systems (the Navy has also incorporated them). They contain no reference to the specific student course and attempt to explain only those features felt to be generic to many CMI systems. The modules are generally given to students at the beginning of training, although they can be used as reference at any time in the course. Students take tests on each module, utilizing the CMI system to acquaint them with standard procedures. [Ref. 112]

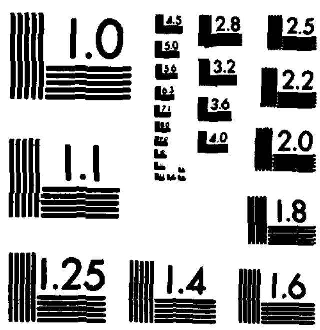
The Orientation Module is entitled "How to be a Successful Student in a Computer-Managed Instructional (CMI) System, or Now You Are Responsible for What You Learn." It is written with simple vocabulary using a light, humorous, and persuasive style. Extensive use of cartoon figures of males and females are used in depicting self-talk sequences of efficient and inefficient CMI students, and is bound as an 8"x11" text. Objectives include recognition of differences between CMI and conventional instruction and recognition of the benefits and features of CMI. [Ref. 113]

The Time Management Module is entitled "Time Management in a Computer-Managed, Individualized Course, or If You Don't Know Where You Are Going, How Will You Know When You Get There." Like the Orientation Module, this one is written in a light narrative style with simple vocabulary and grammar, with extensive cartoons, and bound as an 8"x11" text. The Module describes the concept of time management, its importance in military technical training, reasons why students fail to keep up with their target rates, and ways of dealing with those problems. Students are taught a progress charting technique - a self-monitoring device designed to promote practice of time management skills. [Ref. 114]

The Study Skills Module actually contains four individual units: (1) Reading Comprehension recommends that students ask questions about the new material, draw pictures dealing with relationships between new concepts, or use systematic problem-solving procedures; (2) the Memorization Unit describes and exemplifies the use of mnemonics; (3) the Test Wiseness Unit discusses the use of logical reasoning strategies and gives students numerous practice exercises;

AD-A146 564 COMPUTER-MANAGED INSTRUCTION: THEORY APPLICATION AND SOME KEY IMPLEMENTATION ISSUES(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA M KORBAK MAR 84 2/2

UNCLASSIFIED F/G 5/9 NL



'OPY RESOLUTION TEST CHART

and, (4) the Concentration Management Unit discusses the importance of creating a good mood for effective study and the ways in which negative self-talk and disruption can cause problems. The Study Skills Module is packaged as 8"x11" texts and retained by the students throughout the course of instruction.

Finally, evaluation of the modules has shown that they serve as an effective and beneficial means of preparing the CMI student. The data on the Orientation Module has been scientifically inconclusive, but anectodal data indicates the module is of benefit and does improve student attitudes. The Time Management Module has resulted in significant reductions of course completion time of 11.2 percent [Ref. 115]. And data on the Study Skills Module points to consistent improvement of both attitude and performance of students, particularly from the initially poor students.

These AIS modules demonstrate that training is a natural way of overcoming negative attitudes, instilling motivation, reducing study time, and ultimately promoting more effective and efficient implementation and operation of a CMI curriculum.

The development of the modules led to the recognition of the need to examine educator attitudes and their changing functions with regard to CMI, and to explore the development of specific training packages for the educator. The next Section discusses this follow-on research.

B. THE CMI EDUCATOR

The lack of a coherent role model for the educator in a CMI environment has hampered implementation efforts, and, until recently, has precluded the development of a training program for CMI educators. The use of an implementation strategy that emphasizes user involvement will only occur when the CMI educator is properly oriented and trained, not just in the mechanics of the system, but also in the many roles or functions necessary to be performed effectively for successful implementation and operation of a CMI curriculum. Therefore, this Section explores this aspect, as prefaced by a further look at the CMI educator as a major barrier to effective CMI implementation and operation.

1. Obstacle to CMI Implementation

As alluded to in Chapter I, educator skepticism to educational technology poses as a persistent problem to effective implementation and operation of a CMI curriculum. Figures 6.2 and 6.3, in the preceding Section, list some common obstacles to implementation, several of which are directly related to educators themselves.

Articles pervade the literature with theoretical and experimental analyses of this issue. Direct reasons and causes of educator indifference and resistance frequently consist of the following: (1) ignorance, lack of confidence, and fear of embarrassment [Ref. 116]; (2) cultural rigidity [Ref. 117]; (3) perceived job threat, institutional inertia, and conservatism [Ref. 118]; and, (4) dehumanization of learning [Ref. 119]. Elements of educator indifference, skepticism, or resistance are typically characterized as "major", "significant", or "considerable" importance for the CMI implementation process [Ref. 120].

In view of this, it is not surprising that educators generally have developed negative attitudes toward educational technology. Even educators themselves recognize that their attitudes can serve as the "most important barrier to the successful implementation of CMI programs." [Ref. 121] In many cases, negative attitudes of educators unintentionally foster negative attitudes in their students, compounding the problem.

How does the CMI implementor overcome this barrier? As already mentioned, user involvement, i.e., educator involvement, represents a key mechanism to develop enthusiasm and commitment in the CMI project. Evaluations of numerous CMI projects clearly shows that the CMI educator plays a critical role in the success of a system. If teachers participate actively in the development and implementation phases, they tend to become the best advocates; however, if they are given passive roles or ignored, they will be neutral at best and most likely negative.

The philosophy - just make a computer available and someone is bound to get "hooked" on its potential - has too often failed and proven ineffective for CMI implementation [Ref. 122]. Rather, a systematic training and orientation program is needed, which alleviates fears and apprehensions and explores the ramifications of potential role changes for the CMI educator.

2. <u>The CMI Educator Role</u>

In the decade or more since CMI systems have been adopted in both civilian and military applications, CMI designers and implementors have focused on providing system capabilities and instructional materials to enhance individualized instruction for the student, with little or no attention to the role of the educator in the CMI curriculum. Although it has been recognized that the student's role shifts from a passive to an active learner, questions remain virtually unanswered as to the changing role of the educator, how the educator can best facilitate student learning in a CMI environment, etc. [Ref. 123]

Without clarity of role, educators remain apprehensive, indifferent, skeptic, etc., creating potential problems for the CMI project. For example, in the Sherman School MICA Project, teachers were initially suspicious of CMI, and doubtful that it would work [Ref. 124]. Although trained in the actual mechanics of CMI, only after one full year of operation did their attitudes swing from negative to positive, as they began to perceive how to "fit" into the system, how to utilize system reports effectively, etc. Role changes proved more disruptive than foreseen, and the lack of role definition for the educators nearly caused the failure of the project. Indeed, when a computer system is advertised as the evaluator, diagnostician, prescriber, and manager of individualized instruction, what is the role of the educator?

Given the radical shifts in roles from conventional instruction to CMI, it can be expected that educators will have doubts, fears, or negative attitudes toward unfamiliar roles, particulary if they lack skills or knowledge required to adequately perform them. Only a limited number of systematic studies have been performed which define the problems and challenges unique to the CMI instructional role.

There are two primary roles that CMI instructors theoretically or ideally perform: (1) the Learning Manager Role involves activities of overall planning and implementing of the learning process for CMI students; and, (2) the Learning Facilitator Role involves activities directed at facilitating the performance of individual students in the CMI environment. Figure 6.5 illustrates a breakdown of these two roles into seven more specific CMI educator roles. [Ref. 125]

<u>Learning Manager</u>

1. Planner
2. Implementor

<u>Learning Facilitator</u>

3. Evaluator
4. Diagnostician
5. Counselor
6. Remediator
7. Tutor

Figure 6.5 Ideal CMI Educator Roles

The first role in Figure 6.5 is the Planner, who organizes and coordinates the overall operation of the classroom (or learning center), including decisions about appropriate rewards, placement and frequency of group and individual activities, types of adaptive remediation strategies to be used, and how lectures should be used, if any. The Implementor ensures completion of the plans through the implementation of instructional CMI procedures, and monitors student performance and progress by frequent use of observation, computer-supported reports, or data examination and extraction capabilities.

The Learning Facilitator consists of five specific roles. The Evaluator makes appropriate individual performance evaluations and provides any necessary personal motivation feedback to the students. The Diagnostician diagnoses internal sources of learning problems for those students having difficulty achieving performance criteria. The Counselor advises students about their individual learning problems and appropriate strategies for dealing with these problems. The Remediator selects and prescribes the various individualized strategies judged to be appropriate solutions to the particular learning problems. Finally, the Tutor supports the instructional material when necessary by teaching objectives not able to be acquired by the student through CMI. [Ref. 126]

These roles parallel to some extent the functions of the CMI system (Chapter IV), particularly the five Learning Facilitator roles. The computer performs the functions effectively for the student who progresses normally; however, the state of the art is still too unsophisticated to effectively deal with students who have learning problems. This is primarily the domain of the educator.

3. <u>CMI Educator Role Training</u>

Some researchers have stressed the importance of adequately training CMI instructors in their new roles. As early as 1970, one author had contended that unless educators are provided with <u>meaningful</u> roles in the CMI environment, they will prove more disruptive than embracive [Ref. 127]. And most investigators agree that a dedicated training program for educators is probably the single most important variable to effect educator attitudes [Ref. 128]. Unfortunately, the literature contains few examples of the content and procedures to be used in preparing educators for their new roles; while theories abound, actual practicing procedures are lacking.

As in the training programs for students, the military community leads with a recent design of a CMI Instructor Role Training Package for Air Force and Navy CMI instructors [Ref. 129]. This training package is the outgrowth from another study which compared differences between theoretical instructor roles and actual instructor roles, as perceived by Air Force and Navy CMI instructors [Ref. 130]. In this study significant deviations between the ideal and actual CMI instructor roles (and associated behaviors) indicated that an effective CMI instructor role-training program was needed.

The CMI Instructor Role Training Package developed currently consists of twelve self-instructional printed modules and six group discussions, implemented as a twenty-hour training course. The modules are designed to be used also as reference guides at a later date. The modules contain numerous exercises designed to help the instructor develop alternative motivational, diagnostic, and remedial plans; identify sources of additional information and assistance; and generate checklists or helpful reminders. These exercises are also used as the basis for the six group discussions.

Titles of the twelve training modules include:

1. The Role of the Instructor in CMI.
2. Preparing to be a CMI Instructor.
3. Understanding the Technical Training Student.
4. The Instructor as a Learning Manager - Planning the Environment.
5. The Instructor as a Learning Manager - Planning Instructional Events.
6. The Instructor as an Implementor of CMI Plans.
7. The Instructor as an Evaluator.
8. The Instructor as a Diagnostician.
9. The Instructor as a Remediator.
10. The Instructor as a Counselor and Career Advisor.

11. The Instructor as a Modeler.

12. Coordinating CMI Instructor Roles - Putting It All Together.

Appendix B presents a more detailed description of the content of each module [Ref. 131].

Preliminary evaluation of the package, both qualitative and quantitative, indicates that instructors appreciated the information, found the ideas and concepts stimulating, and in general expressed the feeling that the materials and range of topics were highly relevant and needed areas of CMI instructor training. Use of the information within the modules also appeared to contribute to positive learning center climates and positive student-instructor relationships. [Ref. 132]

Through the development and use of such educator training programs and the specification of optimal instructor roles, the overall effectiveness of the CMI educator can be significantly increased, providing a mechanism to potentially eliminate the skepticism or resistance of educators which stymies evolution of CMI and educational computer use in general.

VII. SUMMARY

The time has arrived when computer use has become so prevalent that it touches man in everyday life. Despite these marvelous advances in computer applications, and despite the vast opportunity inherent in computer technology, computer use in the educational arena has failed to live up to its predicted potential.

With the widespread availability of inexpensive microcomputers, the use of computers in schools has begun to significantly increase. The development of the microcomputer and its continuing reduction of costs, coupled with the advances in videodisk technology, herald drastically different approaches to the educational process. For the first time, commercial software houses recognize the market, and have recently developed some software packages for microcomputer applications of CAI and CMI. Microcomputers may well provide both the adequate technology and the low cost which, in a distributed network environment, will permit wide-scale use of microcomputers for educational instruction.

Unless this is accepted by educators, however, only programming and basic computer operation will be taught in the schools, and the power of the computer for instructional purposes will not be utilized, once again preventing the occurrence of any major changes in education. Technology alone does not drive evolution; it only permits it. The microcomputer can play the role expected of it only if it is utilized in a systematic, well-planned curriculum, in which teachers understand and wholeheartedly support their use. Otherwise, teacher acceptance will remain an impediment to effective implementation and operation of educational computer technology.

As a mechanism for understanding computer use in education, this thesis focuse~~d~~s on Computer-Managed Instruction (CMI). The first ~~two~~ five chapters provide~~d~~ the background, so CMI can ~~could~~ be distinguished from other computer applications in education. Chapter III examine~~d~~s the theoretical basis for CMI, showing that issues in education rather than in computer technology serve as the foundation for CMI.

Chapter IV provided the first look at how computers are used in CMI systems, ~~discussing the~~ discusses aspects of hardware, system configurations, and software. It also present~~ed~~s a comprehensive discussion of the generic functions of CMI systems. Chapter V then united the educational and computer components of CMI as presented in the two previous chapters, and highlighted highlights the diverse nature of CMI applications by focusing on two operational CMI systems.

Chapter VI examines the importance of teacher acceptance of the CMI system during implementation. It presented a review of educator and student attitudes and their effect, and explored training and orientation as a mechanism to assist in the effective implementation and operation of a CMI curriculum.

The opportunity to allow teachers more time to interact with their students by freeing them from the drudgery and mundane tasks of testing, record keeping, and reporting certainly is today, within the bounds of current CMI technology.

In contrast to Computer Aided Instruction (CAI), ~~CAI,~~ which was externally imposed onto the educational field, CMI origins rest in the classroom itself. Because of this and its slow, low-keyed but steady developmental pattern, CMI appears to have a reasonable probability of continued success.

APPENDIX A

CMI SYSTEMS

SYSTEM NAME	COMPUTER SYSTEM	COMPUTER MODE	ACADEMIC LEVEL	CURRICULAR PLAN
AIS (U.S.Air Force)	CYBER 73-14	R	T	L
CMI (Florida State Univ)	CDC 6500	I	U	L
CMI (U.S. Navy)	HONEYWELL 66	R	T	L
CMI (Univ of Texas)	IBM 1500	I	U	M
CTS (U.S. Army)	GTE SYLVANIA	I	T	L
IMS (System Development Corp)	PDP-15	B	E	S
ISS (Pa State Univ)	IBM 370/168	R	U	M
MICA (Sherman School, WI)	UNIVAC 1100	I	E	L
PLAN (Westinghouse Corp)	IBM 370/155	R	E/S	L/B/S
REFLECT (Rockville School, MD)	IBM 1500	I	S	T
SMS (Univ of Illinois)	CDC 6400	I	U	M
TIPS (Univ of Wisconsin)	PDP-11	B	U	L

LEGEND:

COMPUTER MODE	ACADEMIC LEVEL	CURRICULAR PLAN
B Batch	E Elementary	L Linear
R Remote Job Entry	S Secondary	B Block
I Interactive	U University	S Strand
	T Training	T Tree M Menu

APPENDIX B

CMI INSTRUCTOR ROLE TRAINING PACKAGE

Module 1. The Role of the Instructor in CMI. This module introduces the training program, its historical background, and the seven theoretical CMI instructor roles. The first part of this module discusses the differences between CMI and more traditional methods of instruction in terms of the responsibilities of students and instructors and the active versus passive view of the learning process. The second part describes some of the common capabilities of CMI and how these can help instructors perform more effectively and efficiently. Finally, the third part of this module discusses how inadequate training and less-than-ideal systems can cause negative attitudes and describes some general techniques for controlling negative attitudes.

Module 2. Preparing to be a CMI Instructor. This module contains four exercises to help new instructors investigate their own attitudes, opinions, and possible biases about their job as a CMI instructor. It also describes and exemplifies the three basic skills--systematic thinking, stress management, and effective communication--that are essential to perform all CMI instructor roles.

Module 3. Understanding the Technical Training Student. This module describes the growing-up and development processes and the characteristic behaviors, problems, and conflicts of late adolescence and early childhood, Maslow's hierarchy of needs, the role of motivation in learning, and the typical problems that students experience in technical training.

Module 4. The Instructor as a Learning Manager--Planning the Environment. This module begins the academic or professional CMI instructor skill training. It discusses how planning is critical to the efficient operation of a CMI learning environment due to (1) the limited amount of time instructors have to spend with individual students, (2) the variety of student needs that instuctors must address, and (3) the importance of instructors taking control of their job responsibilities. Exercises help instructors identify physical aspects of their learning center for which they need to make plans. The end product of this module is a personalized list of alternative plans, resources, or suggestions for achieving efficiency and consistency in the learning center environment.

Module 5. The Instructor as a Learning Manager--Planning Instructional Events. This module focuses on the instructor as a planner of four different areas of instructional events: (1) building student self-management skills, (2) building student self-directed learning skills, (3) creatively handling computer downtime with extracurricular activities, and (4) developing temporary supplemental instructional materials for main-line materials that are awaiting formal revisions or corrections.

Module 6. The Instructor as an Implementor of CMI Plans. This module discusses how the computer can help instructors monitor and evaluate their plans. It includes exercises for the instructor to learn techniques for planning the effective use of the CMI computer.

Module 7. The Instructor as an Evaluator. This module focuses on the instructor as an evaluator of student performance and notes the importance of using both formal information--obtained from the computer--and informal information--obtained from conversations and observations of students--to evaluate student performance accurately. It also discusses various strategies for providing positive motivational feedback to students. Several exercises in a case-history format are presented to give the instructor practice in applying the model to "real life" situations.

Module 8. The Instructor as a Diagnostician. A four step model depicts the diagnostic process and discusses how to use this model to identify the causes of performance problems. Examples and practice exercises are presented to help instructors diagnose academic, personal, or maturity and life-coping skills problems. Particular emphasis is given to how to use computer reports and other student data available from the CMI system.

Module 9. The Instructor as a Remediator. This module describes treatments to improve study skills, concentration management, and basic skill deficiencies; i.e., the techniques and strategies for assisting the students having academic problems. A five-step model of the remediation process is described and exemplified, and is interrelated to how the computer can assist in presenting effective remediation.

Module 10. The Instructor as a Counselor and Career Advisor . This module discusses effective techniques and resources for helping students with their personal problems. In numerous exercises, instructors identify responsible and reputable referral sources for students experiencing personal problems. This module concludes with two case-history exercises.

Module 11. The Instructor as a Modeler. This module discusses (1) the implications of the fact that students often model or mimic the behavior of instructors and (2) how modeling can be used to help students who lack maturity and life-coping skills. In numerous exercises, instructors evaluate their learning center behaviors in terms of the model they present and make plans for improving that image.

Module 12. Coordinating CMI Instructor Roles--Putting It All Together . This module summarizes the previous eleven modules through the use of several case histories, which combine information presented in the other modules. After several case histories exemplifying efficient and inefficient ways to combine instructor roles, instructors complete three case history exercises.

LIST OF REFERENCES

1. Kay, Harry, Dodd, Bernard, and Sime, Max, Teaching Machines and Programmed Instruction, p. 11, Penguin Books Inc., 1968.

2. Kulik, J.A., Kulik, C.C., and Cohen, P.A., "A Meta-Analysis of Outcome Studies of Keller's Personalized System of Instruction," Memo to the Faculty, Ann Arbor, Michigan, 1980.

3. Rizza, Peter J., "Computer-Based Education (CBE): Tomorrow's Traditional System," Children in Contemporary Society, v. 14, p. 31, Fall 1981.

4. Ibid., p. 31.

5. Potts, Ann S., A Study of Factors Affecting the Success of Computer-Assisted Instruction in Selected Colleges and Universities, Ph.D. Thesis, Florida Atlantic University, Boca Raton, Florida, August 1979, pp. 13-18.

6. Skinner, B.F., "The Science of Learning and the Art of Teaching," Harvard Educational Review, v. 24, pp. 86-97, Spring 1954.

7. Aiken, Robert M. and Braun, Ludwig, "Into the 80's With Microcomputer-Based Learning," Computer, v. 13, p. 12, July 1980.

8. Potts, p. 16.

9. Watson, Paul G., Using the Computer in Education, p. 7, Educational Technology Publications, 1972.

10. Brudner, Harvey J.,"Computer-Managed Instruction," Science, v. 162, p. 970, November 29, 1968.

11. Mitzel, Harold E., An Examination of the Short-Range Potential of Computer-Managed Instruction, paper presented at the CMI Conference, Chicago, Illinois, November 6-8, 1974.

12. Furr, Coleman, The Effect of Upgraded Testing on Student Learning in Computer Managed Instruction, Ph.D. Thesis, United States International University, San Diego, California, 1982.

13. Baker, Frank B., Computer-Managed Instruction, pp. 4-5, Educational Technology Publications, 1978.

14. Institute for Defense Analysis Report P-1375, Cost Effectiveness of Computer-Based Instruction in Military Training, by Jesse Orlansky and Joseph String, p. 22, April 1979.

15. Watson, p. 31.

16. Buck, John A., "Federal Aviation Administration Computer-Based Training Report," Journal of Computer-Based Instruction, v. 8, p. 53, February 1982.

17. Navy Personnel Research and Development Center Report NPRDC TN 82-17, Computer-Based Education and Training Functions, by R.D.V. Peters, p. 2, May 1982.

18. Air Force Human Resources Laboratory Report AFHRL TR 79-74, Computer-Assisted Instruction in the Context of AIS, by W.E. Lewis and R.W. Mahany, p. 8, March 1980.

19. Baker, p. 44.

20. Lewis and Mahany, p. 8.

21. Ibid., pp. 8-9.

22. Federico, P., Changes in the Cognitive Components of Achievement As Students Progress Through Sequential Instruction, paper presented at the Annual Meeting of the American Educational Research Association, New York, New York, March 1982.

23. O'Neil, H.F., Jr., ed., Computer-Based Instruction, p. 128, Academic Press, 1981.

24. Bork, Alfred, "Educational Technology and the Future," Journal of Educational Technology Systems, v. 10(1), p. 4, 1981-82.

25. Bloom, Benjamin S., Human Characteristics in School Learning, p. 4, McGraw Hill Book Company, 1976.

26. Ibid., pp. 6-18.

27. Federico, P., "Individual Differences in Cognitive Characteristics and Computer-Managed Mastery Learning," Journal of Computer-Based Instruction, v. 9, pp. 10-18, Summer 1982.

28. The Rand Corporation Report R-1701-AF, Method of Designing Instructional Alternatives, by P. Carpenter, April 1977.

29. Training Analysis and Evaluation Group Report 78, An Assessment of Individualized Instruction in Navy Technical Training, by M. Zajkowski, p. 12, November 1979.

30. Ibid., pp. 11-12.

31. Spuck, Dennis W. and Owen, Stephen P., "Individualized Instruction: Its Structure and Management with Computer Assistance," Educational Technology, v. 16, pp. 18-26, 1976.

32. Bozeman, William C., "Computer-Managed Instruction: State of the Art," Automated Educational Data Systems Journal, v. 12, p. 118, Spring 1979.

33. Training Analysis and Evaluation Group Report 14, Computer Managed Instruction in Navy Training by M.G. Middleton, C.J. Papetti, and G.S. Micheli, p. 40, March 1974.

34. Gagne, Robert M., The Conditions of Learning, p. 18, Holt, 1965.

35. Baker, p. 22.

36. Ibid., p. 26.

37. Ibid., p. 28.

38. Heines, Jesse M., The Use of Interactive, Computer-Managed Instruction to Control the Quality of Self-Paced Training, Ph.D. Thesis, Boston University, Boston, Massachusetts, May 1979, p. 11.

39. Baker, pp. 361-362.

40. O'Neil, p. 57.

41. Ibid.

42. Air Force Human Resources Laboratory Report AFHRL TP 81-37, Microterminal/Microfiche System for Computer-Based Testing and Interactive Instruction, by J.P. Lamos, January 1982.

43. Thomas, Rex and Gustafson, Brian, "The Design, Development, and Evaluation of a Low-Cost Computer-Managed Spelling System," *Journal of the Association for Educational Data Systems*, v. 16, pp. 168-176, Spring 1983.

44. Orlansky and String, pp. B-8-12.

45. Kearsley, Greg, *Computer-Based Training*, p. 67, Addison-Wesley, 1983.

46. Training Analysis and Evaluation Group Report 44, *Computer-Managed Instruction at Remote Sites by Satellite*, by Kenneth A. Polcyn, December 1976.

47. Baker, p. 331.

48. Ibid., p. 333.

49. Kearsley, p. 81.

50. Training Analysis and Evaluation Group Report 141, *The Application of Distributed System Architectures for Computer-Based Instructional Systems in the Naval Education and Training Command*, by B.L. Capehart and C.L. Morris, February 1983.

51. Kearsley, p. 25.

52. O'Neil, p. 46.

53. Ibid., p. 45.

54. Middleton, Papetti, and Micheli, p. 40.

55. Marshall, Alan P., "Development of a Transportable CBI System," *Journal of Computer-Based Instruction*, v. 10, pp. 66-69, Autumn 1983.

56. Kalisch, Stanley J., "Some Directions of Present and Future Computer-Managed Instruction Systems-Why the Differences," *Journal of Educational Technology Systems*, v. 7, p. 26, 1978-79.

57. Air Force Human Resources Laboratory Report AFHRL TR 79-42, *Low Cost Computer Aided Instruction/Computer Managed Instruction (CAI/CMI) System: Feasibility Study*, by L.M. Lintz, C.J. Nix, and T. Tate, pp. 10-68, December 1979.

58. Baker, pp. 41-101.

59. O'Neil, pp. 23-64.

60. Navy Personnel Research and Development Center Report NPRDC 80-10, *Theoretical Definition of Instructor Role in Computer- Managed Instruction*, by B.L. McCombs, pp. 18-25, March 1980.

61. Peters, pp. 6-14.

62. Leiblum, Mark D., "Computer-Managed Instruction: An Explanation and Overview," *Journal of the Association for Educational Data Systems*, v. 15, pp. 126-142, Spring 1982.

63. Peters, pp. 6-14.

64. Lintz, Nix, and Tate, pp. 28-36.

65. Peters, pp. 8-14.

66. Navy Personnel Research and Development Center NPRDC Technical Note 77-1, *Feedback in Programmed Instruction Text Material*, by Raymond W. Kulhavy, p. 3, October 1976.

67. Benson, Jean S. and Yeany, Russel H., *Generalizability of Diagnostic-Prescriptive Teaching Strategies Across Student Locus of Control and Multiple Instructional Units*, paper presented at the Annual Meeting of the American Educational Research Association, Boston, Massachusetts, April 7-11, 1980.

68. Gaynor, Patricia, "The Effect of Feedback Delay on Retention of Computer-Based Mathematical Material," *Journal of Computer-Based Instruction*, v. 8, pp. 28-34, November 1981.

69. Navy Personnel Research and Development Center Report NPRDC TR 83-13, *The Effects of the Timing of Feedback on Long-Term Knowledge Retention*, by K.A. Lockhart and B. Dubois, p. 25, February 1983.

70. Baker, p. 300.

71. Peters, pp. 8-12.

72. Leiblum, pp. 132-138.

73. Mitzel, pp. 34-35.

74. Anglin, Leo, "MICA at Sherman School (An Application of Computer Managed Instruction)," *Journal of the Association for Educational Data Systems*, v. 8, pp. 34-40, Winter 1974.

75. Bozeman, pp. 124-125.

76. Furr, p. 16.

77. Hansen, Duncan N., Ross, Steven M., Bowman, Harry L., and Thurmond, Paul, *Navy Computer Managed Instruction*, pp. 6-14, Educational Research Services, 1975.

78. Navy Personnel Research and Development Center Report NPRDC SR 80-33, *Computer-Managed Instruction in the Navy*, by Nick Van Matre, p. 1, September 1980.

79. Middleton, Papetti, and Micheli, p. 4.

80. Hansen, Ross, Bowman, and Thurmond, p. 32.

81. Training Analysis and Evaluation Group Report 119, *Analysis of Factors Affecting the Performance of the Navy's Computer-Managed Instructional System*, by William M. Swope, James M. Corey, Richard M. Evans, and Charles L. Morris, p. 25, April 1982.

82. Ibid., p. 24.

83. Ibid., pp. 28-34.

84. Van Matre, pp. 1-7.

85. Ibid., pp. 1-5.

86. Van Matre, Nick, *The Many Uses of Evaluation in the Navy's CMI System*, paper presented at the Annual Meeting of the Association for the Development of Computer Based Instructional Systems, Dallas, Texas, March 1-4, 1978.

87. Van Matre, CMI in the Navy, p. 6.

88. Willis, Cam, *Successful Implementation of Computing Technology in Schools Through Teacher Education, Professional Development and Support*, paper presented at Annual Convention of the Association for Educational Data Systems, 20th, Orlando, Florida, May 10-14, 1982.

89. Fullan, Michael and Park, Paul, "Curriculum Implementation," Ontario Ministry of Education, 1981.

90. Kearsley, pp. 133-143.

91. Ibid., p. 134.

92. Ibid.

93. Ibid., p. 135.

94. Willis, p. 75.

95. Gordon, Sheldon P., "Faculty Training and Development in Academic Computing," Journal of Computer-Based Instruction, v. 10, p. 51, Summer 1983.

96. Schile, Gerald L., Effectiveness of Using a Microcomputer to Provide Remedial Instruction Prescriptions in a Navy Technical Training Course, Ph.D. Thesis, Memphis State University, Memphis, Tennessee, May 1983.

97. Johnson, James W., "Education and the New Technology: A Force of History," Educational Technology, v. 21, pp. 18-20, October 1981.

98. Howey, Christopher L., The Effects of Different Feedback Strategies on the Attitude of Students Involved in Computer-Assisted Instruction, Ph.D. Thesis, Wayne State University, Detroit, Michigan, 1983.

99. Scheirer, M.A. and Kraut, R.E., "Increasing Educational Achievement via Self Concept Change," Review of Educational Research, v. 49, p. 180, November 1, 1979.

100. Ibid., p. 188.

101. Department of Defense, Attitudes and Performance of Military Students in Computer-Based Technical Training, by K.K. Tatsuoka, A.L. Misselt, and P. Maritz, 1978.

102. Air Force Human Resources Laboratory Report AFHRL TR 75-4, Impact of Computer-Based Instruction on Attitudes of Students and Instructors, by A.T. King, pp. 7-20, May 1975.

103. Navy Personnel Research and Development Center NPRDC TR 82-19, Computer-Managed Instruction in Navy Technical Training, by C.A. Robinson, E.A. Tomblin, and A. Houston, p. 1, December 1981.

104. Van Matre, CMI in the Navy, p. 9.

105. Hillelsohn, Michael J. and Kearsley, Greg P., "Human Factors Considerations for Computer-Based Training," Journal of Computer-Based Instruction, v. 8, p. 81, May 1982.

106. Air Force Human Resources Laboratory Report AFHRL TR 79-20, Computer-Managed Instruction: Development and Evaluation of Student Skill Modules to Reduce Training Time, by B.L. McCombs and J.L. Dobrovolny, p. 13, August 1979.

107. Dobrovolny, Jacqueline L., Time Management Skill Training and Procedures for Increasing Student Efficiency in a Computer-Managed Instructional Environment, paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, California, April 1979.

108. McCombs and Dobrovolny, p. 14.

109. Ibid., pp. 14-16.

110. King, p. 12.

111. McCombs and Dobrovolny, pp. 8-28.

112. Ibid., pp. 34-37.

113. Air Force Human Resources Laboratory Report AFHRL TR 79-14, Orientation/Time Management Skill Training, by J.L. Dobrovolny, B.L. McCombs, and W.A. Judd, pp. 85-114, July 1979.

114. Dobrovolny, pp. 1-9.

115. Ibid., p. 1.

116. Gordon, pp. 51-53.

117. Duncan, Karen A., Presidential Address for the 1978 Annual Conference, paper presented at the Annual Conference of the Association for the Development of Computer-Based Instructional Systems, National Conference, Dallas, Texas, March 2, 1978.

118. Norris, William C., "Via Technology to a New Era in Education," Phi Delta Kappan, v. 58, p. 453, February 1977.

119. Lewis, R., "Education, Computers, and Micro-Electronics," T.H.E. Journal: Technological Horizons in Education, v. 8, p. 48, January 1981.

120. Wollitzer, Peter A., "Faculty Perspectives on Computer-Based Education," Journal of Computer-Based Instruction, v. 3, p. 77, February 1977.

121. Hansen, Ross, Bowman, and Thurmond, p. 63.

122. King, p. 25.

123. McCombs, pp. 2-6.

124. Baker, p. 283.

125. McCombs, p. 15.

126. Ibid., pp. 13-18.

127. Watson, p. 113.

128. King, p. 22.

129. Navy Personnel Research and Development Center Report NPRDC SR 83-43, Evaluation of the CMI Instructor Role Training Program in the Navy and Air Force, by K.A. Lockhart, June 1983.

130. McCombs, pp. 3-24.

131. Lockhart, pp. A-1-3.

132. Ibid., pp. 21-24.

BIBLIOGRAPHY

Air Force Human Resources Laboratory Report AFHRL TP 83-16, _Where Angels Fear To Tread - The Impact of CBI Upon Instructors_, by Worth Scanland, March 1983.

Countermine, Terry and Singh, Jane M., "A Computer-Managed Instruction Support System for Large Group Individualized Instruction," _Journal of Computer-Based Instruction_, v. 4, August 1977.

Davis, John D., "The Navy CMI System: A Brief Overview," _Journal of Educational Technology Systems_, v. 6(2), 1977-78.

Dean, Christopher and Whitlock, Quentin, _A Handbook of Computer Based Training_, Nichols Publishing Company, 1983.

De Witte, Paul, "A Software Package for CMI," _Computers and Education_, v. 3, 1979.

Ellis, John A., _A Comparative Evaluation of Computer-Managed and Instructor-Managed Instruction_, paper presented at the Annual Meeting of the Association for the Development of Computer Based Instructional Systems, Dallas, Texas, March 1-4, 1978.

Federico, P., "Changes in the Cognitive Components of Achievement as Students Proceed Through CMI," _Journal of Computer-Based Instruction_, v. 9, Spring 1983.

Gundlach, Aly, "Managing Instruction with a Micro," _Educational Computer_, v. 1, May-June 1981.

Hall, Keith A., _Taxonomy of Instructional Strategies for Computer Based Education_, paper presented at the Annual Convention of the Association of Educational Data Systems, 20th, Orlando, Florida, May 10-14, 1982.

Hannum, Dave, "A Guide to Computer-Based Training Systems," _Interface Age_, v. 6, October 1981.

Lippey, Gerald, "Ten More Pitfalls in CMI Development," _Journal of Computer-Based Instruction_, v. 2, August 1975.

Mayo, G. Douglas, "Ten Pitfalls in CMI Development," _Journal of Computer-Based Instruction_, v. 1, February 1975.

Mitzel, Harold E., "On the Importance of Theory in Applying Technology to Education," Journal of Computer-Based Instruction, v. 7, May 1971.

Montague, William, "Quality CBI Depends on Quality Instructional Design and Quality Implementation," Journal of Computer-Based Instruction, v. 10, Autumn 1983.

Navy Personnel Research and Development Center NPRDC TR 75-38, An Evaluation of Computer-Managed Instruction in Navy Technical Training, by Stuart B. Carson and Kirk A. Johnson, May 1975.

Navy Personnel Research and Development Center NPRDC TR 78-15, Immediate vs Delayed Feedback in a Computer-Managed Test: Effects on Long-Term Retention, by Persis T. Sturges, March 1978.

Navy Personnel Research and Development Center NPRDC TR 79-21, Discriminating Between Failures and Graduates in a Computer-Managed Course Using Measures of Cognitive Styles, Abilities, and Aptitudes, by P. Federico and David B. Landis, June 1979.

Navy Personnel Research and Development Center NPRDC TR 79-30, Predicting Student Performance in a Computer-Managed Course Using Measures of Cognitive Styles, Abilities, and Aptitudes, by P. Federico and David B. Landis, August 1979.

Navy Personnel Research and Development Center NPRDC TR 81-6, Computer-Managed Instruction in the Navy: A Comparison of Two Student/Instructor Ratios in CMI Learning Centers, by Nick Van Matre, Marc Hamovitch, Kathleen A. Lockhart, and Lisa Squire, February 1981.

Navy Personnel Research and Development Center NPRDC TR 82-45, Instructor's Role in Individualized Training: A Survey of Two Computer-Managed Courses, by Kirk A. Johnson and Linda L. Graham, May 1982.

Navy Personnel Research and Development Center NPRDC TR 82-53, An Evaluation of Individualized, Job-Specific Maintenance Training, by Kirk A. Johnson, Linda L. Graham, and Stuart B. Carson, July 1982.

Training Analysis and Evaluation Group Report 89, Computer Based Instructional Systems - 1985 to 1995, by Gene S. Micheli, August 1980.

Training Analysis and Evaluation Group Report 105, Economic Analysis of Individualized and Conventional Instruction, by James M. Corey, June 1981.

Training Analysis and Evaluation Group Report 117, A Comparison Of Individualized and Conventional Instruction in Navy Technical Training, by Eugene R. Hall, May 1982.

Willis, Jerry, "Computer Managed Instruction: Can You Use It," Educational Computer, v. 3, May-June 1983.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22314	2
2.	Library, Code 0142 Naval Postgraduate School Monterey, California 93943	2
3.	Curricular Office, Code 37 Computer Technology Naval Postgraduate School Monterey, California 93943	1
4.	Assistant Professor Dan C. Boger, Code 54Bk Department of Administrative Sciences Naval Postgraduate School Monterey, California 93943	2
5.	LCDR Michael Korbak, Jr., USNR 913 Haines Drive McKees Rocks, Pennsylvania 15136	2

END

FILMED

1 84

DTIC