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ABSTRACT

The goal of Project IMPACT is to provide the U.S. Army with an effective, efficient, and economical computer-assisted instruction (CAI) system in a total system framework. This paper reviews the a) reasons for establishment of Project IMPACT, b) nature of the project and its relevance to needs of the Army, c) reasons why the Army needs to develop its own capability in CAI, and d) directions and prospects for delivery of specifications for an operational CAI system for the Army within the next two years. (JK)

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Robert J. Seidel

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U.S. Continental Army Command
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HUMAN RESOURCES RESEARCH ORGANIZATION
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The Human Resources Research Organization (HumRRO) is a nonprofit corporation established in 1969 to conduct research in the field of training and education. It is a continuation of The George Washington University Human Resources Research Office. HumRRO's general purpose is to improve human performance, particularly in organizational settings, through behavioral and social science research, development, and consultation. HumRRO's mission in work performed under contract with the Department of the Army is to conduct research in the fields of training, motivation and leadership.

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Prefatory Note

The research and development efforts described herein were performed at the Human Resources Research Organization, Division No. 1 (System Operations), Alexandria, Virginia. Dr. Seidel is Program Director of Project IMPACT, Prototypes of Computerized Training for Army Personnel.

CURRENT STATUS OF COMPUTER-ADMINISTERED INSTRUCTION WORK UNDER PROJECT IMPACT

Robert J. Seidel

INTRODUCTION

This paper is a review of the status and progress of the Human Resources Research Organization's Project IMPACT, a comprehensive advanced development project designed to produce prototypes of computerized training for Army personnel. The discussion will follow this order: first, the reasons for the establishment of Project IMPACT—computer-administered instruction (CAI) for the Army; second, the nature of Project IMPACT and its relevance to meeting the needs of the Army; third, the reasons for the Army's developing its own capability in CAI, rather than letting someone else do it; and last, the directions and prospects for delivery of specifications for an operational CAI system for the Army within the next two years.

Why Does the Army Need CAI?

The combination of shrinking financial resources and a smaller and largely volunteer Army will increase the demands made on service personnel, will increase the importance of each individual soldier, and will pose even more difficult problems in training. The need for more effective and efficient training will be greater and the training will be more difficult to achieve. The training must be adequate to deal with widespread student differences, to provide an increasing number of complex skills, and to use an even smaller number of skilled instructors. When it is developed as a comprehensive and total system, computer-administered instruction is the most promising approach available to meeting these new training demands.

In recognition of these demands, the Army established Project IMPACT in Fiscal Year 1968 as an advanced development effort to provide a means to achieve these goals. The goal of Project IMPACT is to provide for the Army an effective, efficient, and economical computer-administered instruction system in a total system framework. By "effective," we refer to maximizing the achievement of the students and the instructors to a greater extent than is possible in the traditional classroom. By "efficient," we refer to maximum productivity per unit time on the part of instructors, administrators, and students. By "economical," we mean that the cost and use of resources must not exceed those required for a comparable effective non-CAI instructional system. As more and more evidence is gathered regarding the cost of computer-administered instruction, it becomes apparent that with an operational CAI instruction system, significant dollar savings can be achieved. A CAI type of system is largely a capital-intensive system, where hardware and software costs, although initially quite large, can be amortized over a period of years so that after the first one or two years, a considerable portion of the initial investment is returned to increase speed and effectiveness of instruction. Conventional instruction, on the other hand, is largely a labor-intensive type of system. No matter how effective it becomes, the costs of labor are cumulative and, with raises plus inflation, increase each year. Therefore, the costs of this type of instructional system will increase markedly year by year (Randall and Blaschke, 1968).

The "A" in our CAI system must be interpreted as "administered" rather than "assisted," as is the case in a number of other projects. By the use of the term administered, we emphasize that the capacities of the computer for rapid processing, vast storage and retrieval, and adaptivity are *tools* that are used to facilitate the matching of instruction to the training of individual students. These tools permit the instructional design team to extend their intelligence through models of instruction and through various sets of rules, tailored to the changing individual student as a means of increasing the effectiveness and efficiency of the instruction.

The Nature and Relevance of Project IMPACT

Our emphasis on the concept of a *total system* is much more than a desire to capitalize on the use of a popular term. The approach of Project IMPACT is to develop concurrently these four facets of a total system:

(1) Instructional content
(2) Hardware
(3) Software
(4) Instructional Decision Models (Strategies) for the presentation of subject matter

The Project is organized to keep these facets in step with each other over a span of two generations of CAI systems and four successive cycles of development and testing. The initial two cycles covering the development and test of a "breadboard" CAI system have been completed. The second two cycles are directed to refining all the facets of the system for prototype development and to test, evaluate, and deliver to the Army, specifications for an operational, instructional system at the end of the evaluation.

The initial instructional content, chosen for a number of pedagogical and pragmatic reasons, was COBOL, the computer programming language. The subject matter provided the instructional vehicle around which the other three facets of our effort were developed. The hardware chosen for the first generation was not based upon a single hardware manufacturer's available equipment. In keeping with the aim of designing specifications for a total system, the hardware was chosen to solve the functional requirements for this system, and thus, we selected the best the market could provide within given cost constraints at the time the design of the first generation of the system was frozen. This led to a combination of equipment from five manufacturers chosen because of the status of their devices with respect to the state-of-the-art. The main frame of the hardware, an IBM 360/40 or IBM 370/45[1] with components, was interfaced with instructional hardware located at HumRRO in 12 student stations, which included a cathode ray tube, film projector, keyboard, and light pen. The software development in this total system includes the modification of an existing CAI language (IBM's Coursewriter III—Version 2) to provide an expanded capability for interaction between student and computer and author and computer. Advancements made along this facet of development will be discussed later.

The heart of the CAI effort is the evolutionary development of Instructional Decision Models (IDMs) consisting of sets of rules for matching the presentation of instructional material to the individual student's momentary needs, interests, and capabilities. The overall IDM approach involves (a) mapping the subject matter, (b) analyzing student characteristics, (c) developing decision rules for presenting subject matter as a function of a student's characteristics, and (d) evolving an algorithmic representation of the decision rules. The approach also includes a combination of variables for the decision-manipulated rules and correlational variables. The correlational variables that

[1]Identification of products is for research documentation purposes only and does not constitute an official endorsement by HumRRO or by the Department of the Army.

relate significantly with performance are then plugged in as part of the decision rules on the next IDM iteration.

The initial manipulative decision rules were based upon a combination of correctness or incorrectness of the student's response and his degree of confidence in the response. This provided an indication of the individual's state of skill development pertaining to the concepts at hand. Valid confidence testing (VCT) also gave the student rational reinforcement for telling the system what he did *not* know, as well as what he did know. Next, the IDM provided the student stimulus support (prompting or confirmation) only in the amount required to keep him coping with the materials. An earlier study demonstrated that students receiving an excessive amount of support during learning were hindered in criterial performance requiring synthesis of what they had learned when being tested. (For this rationale, see Seidel and Project IMPACT Staff, 1969; Seidel and Hunter, 1968).

At the same time, potentially useful variables were measured and then correlated with criterion performance (the writing of computer programs). These variables included a battery of entry characteristics measures, that is, a test of the student's intellect as it relates to different types of performance requirements (Guilford, 1967; Bunderson, 1967). In addition, we also correlated the student's expectation of his performance with how well he actually did perform in order to determine usefulness of this factor as a predictor of student achievement. This, then, constituted our breadboard instructional system.

During the testing period, liaison was maintained with the U.S. Continental Army Command (CONARC) and also with Fort Belvoir; the latter supplied students from Project TRANSITION. This work was conducted by an interdisciplinary team with expertise in behavioral science or research psychology, computer science, applied mathematics, electrical engineering, and instructional programming.

Why Should the Army Undertake the Development of a CAI System?

Granted that the need exists for a comprehensive development of CAI for the Army and that the approach taken by HumRRO and the Army through IMPACT is a sound one, questions remain—Why should the Army undertake the systems development of CAI? Why not let one of the other services do this? Why not let some other government agency undertake the task? Why not let industry do it?

It is a simple fact that no one else—I repeat, no one else—is undertaking this development. Because there is government funding of various CAI efforts and because industry has made some investments in CAI, some may question my assertion. There are commercially available student consoles: IBM has a special CAI computer, the 1500 Hardware Configuration; RCA and General Electric, for example, have computers that can handle some form of CAI. Why can't the Army simply take the fruits of these efforts and apply them? Because computer manufacturers are principally *selling* equipment to the broadest possible market. Because equipment does *not* constitute a system. Because the Army has no firm basis for evaluating the competing claims of the equipment manufacturers. Because the Army must be able to provide the specifications for equipment appropriate to its own CAI system, rather than attempting to build a system around existing equipment. IBM, recognizing this deficiency, has stopped development of the 1500 Configuration. RCA has left the computer business completely, according to the *Wall Street Journal* (September 17, 1971).

Army training requirements are sufficiently unique to demand specifically tailored system design. The IMPACT approach is designed to meet the Army's operational needs without the constraints of a vested interest in a particular piece of equipment. Further, IMPACT is designed to provide functional requirements that can guide the Army in future computer acquisitions. A total system approach to CAI is not being developed elsewhere, although many important and useful components of CAI systems have been and are being developed—for example, CAI-author languages. IMPACT has incorporated items developed elsewhere into the total system, thus avoiding unnecessary duplication of effort. For example, our software that enables authors to create, modify, and otherwise manage instructional text (IMPACT Staff, 1971), interfaces with Coursewriter III, a language already developed by IBM. The IMPACT text management capability is therefore compatible with IBM 360 or 370 operating systems. This capability is not intended to be a universal, machine-independent set of software, but it can be re-implemented on machines of other manufacturers following a conversion effort. Developing a system to meet Army needs is an important feature of the IMPACT development plan.[1] Service training requirements, facilities, problems, and situations tend to be unique.

Our recent change in sponsorship from the U.S. Army Research Office to CONARC has served to bring us closer to these operational requirements. Our cooperation with the Fort Monmouth Signal School CAI Project will continue to provide one of the initial focal points for coordinated application of our findings. Ultimately, then, IMPACT's advanced development effort will provide the Army with a prototype operational system—its own capability for developing sound, effective CAI materials. The generalized logic of the computer programs will be designed and documented for use by technically unsophisticated personnel so that instructors, lesson designers, and subject-matter experts will be able to modify a course for their particular purposes.

Through the development of a useful family of Instructional Decision Models (IDMs), the programs of instruction will be adaptable to the momentary capabilities of the individual trainee and the content will be made relevant to specific job requirements of the individual. Based upon the iterative approach to developing the four facets of the total instructional system noted earlier, the products will also include design requirements for hardware configuration for operationally implementable Army CAI. In the software area, they will include computer programs to facilitate interaction between author-computer, trainee-computer, and administrator-computer. User documentation will be provided to enable easy implementation of these products. Because of the shortfall in funding, delivery of the specifications for an operational CAI system has been delayed from the original goal of FY 1972 until the latter part of FY 1974.

The three items of most significance to this discussion are (a) what products are available *now* from Project IMPACT efforts? (b) In what directions are we headed? and (c) What guidelines and suggestions do we have for the Army user in order to permit him to take advantage of the IMPACT delivery of a CAI system at the projected date?

We have developed guidelines as a result of our initial testing that will be applicable for systematic construction of instructional materials and IDMs. We have produced a set of software to enable multiple users, students, and authors to simultaneously take advantage of a CAI system (IMPACT Staff, 1970). We have also developed a software product that provides a flexible and easy-to-use technique for creating, managing, and modifying instructional or text materials to be presented by the computer in a CAI environment.

One of the problems in course development activities is the creation of lesson content by personnel unfamiliar with computer programming. The IMPACT capability permits the unsophisticated author to accomplish this after approximately 20 minutes of training. Moreover, the flexibility of our software allows these functions of creation, modification, and management of materials to be kept separate from the logic by which these materials are sequenced by the computer system (IMPACT Staff, 1971). Thus, we have an easy-to-use text-managing capability that places minimal demands upon authoring

[1] A Project IMPACT Technical Development Plan on instructional model prototypes attainable in computerized training was produced in December 1966.

personnel. Further, this software was designed to interface with and build upon existing CAI languages, such as Coursewriter III or Tutor, thus avoiding the unnecessary cost of duplicating language developments accomplished elsewhere.

The software products are transportable to any machine provided that a conversion or re-implementation of the logic takes place. Finally, we have developed an approach toward the systematic analysis of instructional materials based upon a modular framework; this framework permits a melding of the systems engineering requirements set forth in CONARC Regulation 350-100-1 (CONARC, 1968),[1] with the use of the computer for development and for presentation of instruction.

Let us consider the guidelines from the data analysis on the first IDM. In essence, the basic concept of specific types of intellectual capabilities required for specific kinds of tasks was substantiated. We do not think that we have sufficient numbers of students to make broad generalizations. However, the data from our study, when combined with those of Bunderson and his associates (Dunham and Bunderson, 1968; Dunham, Guilford and Hoepfner, 1968), and with earlier results from other researchers (Guilford, 1967), clearly support the notion that different kinds of tasks (e.g., problem-solving vs. procedural skills, or thinking types of activities vs. motor activities like heavy wheel maintenance) demand specific and unique student abilities for adequate performance. In other words, there are differential performance predictors appropriate to different tasks. The implication of this is that general tests are inadequate as aids to treat students' individuality. Moreover, presentation of instruction should capitalize on the unique pattern of abilities of each student. The match involves altering the form of the materials to fit the student, and also using those tests that turn out to be important for the tasks to be taught.

In our study, for example, the significant differential performance predictors in the introductory part of the course were different from those that were useful for prediction of criterion performance in the more complex stages. In the introductory part of the course, five factors proved to be significant predictors. They were associative or primitive memory, general reasoning, a general quantitative skill, and something even more interesting, student expectancy just prior to the criterion or post-test. The more complex portion of the course yielded strikingly different predictor variables. Eleven factors were shown. The primary predictive variable was figural adaptive flexibility, the capability to change set in order to meet new requirements imposed by figural problems. Perceptual speed, ability to make comparisons rapidly and accurately, appeared useful. Student expectancy (self-assessment) appeared important at an *earlier* point in this portion, at the pre-test. Finally, a higher level memory factor, chunking memory, was shown.

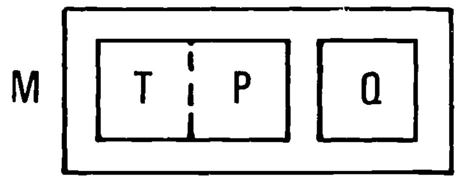
As a result of these findings, we are going to document guidelines for instructional modeling application that will capitalize upon differential performance prediction. We will suggest that entry characteristic test batteries be used for placement of students in courses based upon the task requirements and how much of those abilities individual students possess. Also, we will now advise that the student expectation of performance be tested periodically during instruction and that, when the discrepancies between his expectation and actual performance become too large, or increase from an earlier measure, remedial instruction be provided. This approach will keep the student's expectation realistically in line with his actual performance and will avoid frustration.

Another guideline that will be documented relates to the development of a framework for course construction, which, as noted, is in line with a meeting of the requirements for establishing terminal and enabling objectives clearly from the outset of instructional development. There will be an opportunity to separate alternative instructional strategies from the mainline modular development of the instructional content.

[1] U.S. Continental Army Command. *Systems Engineering of Training (Course Design)*, CONARC Regulation 350-100-1, Fort Monroe, Va., February 1968.

Essentially, we have made provision for any course to be broken down into subsets of terminal behavioral objectives, and at the smallest possible level, we call this a "module of instruction." A Module may be thought of as perhaps a single concept (Figure 1) and involves a narrative section in which the student is given the concept, a practice section in which the student has hands-on experience in using or applying the concept, and, finally, a quiz section that tests the degree of mastery by the student of the terminal objectives set forth for that Module. (As currently applied, a Module can be completed, on the average, in approximately 15 minutes.)

A Unit or Module of Instruction



M = Module, a unit of instruction derived from Behavioral Objectives

T = Concept presentation (Telling)

P = Practice with the concept ("hands on")

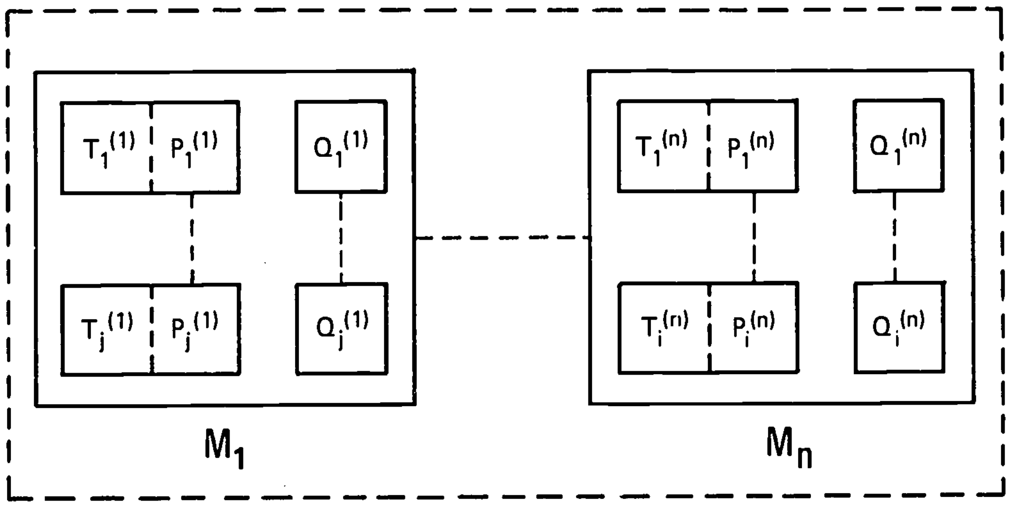
Q = Quiz on the Behavioral Objectives of the unit

Figure 1

As applied to any course, this design structure would be accomplished in the following way. The Course as a whole is defined as the total set of behavioral objectives and the way in which one goes about achieving them relevant to a given target population. Within the Course, Divisions are defined in terms of their respective input requirements (students' entry characteristics) and output (behavioral objectives). In other words, the set of behavioral objectives stated for the Course as a whole is partitioned into major component objectives. At present, in the COBOL2 course, it appears that Divisions within the course will form a linear (complete) order, that is, students must pass through them in a fixed sequence. (This need not be the case with other courses of instruction where systems engineering has shown that certain Divisions can be achieved independent of the achievement of objectives in other Divisions.) Within each Division (D) of the Course, a number of Modules (e.g., M_1 through M_n) are defined, again in terms of inputs and outputs. These Modules form a partial order (a graph, a map) on which students or system could progressively impose a particular linear sequence. Figure 2 illustrates the variability by dotted connecting lines between alternate forms of T-, P-, and Q-Sections of a Module. Figure 3 shows how this framework, called the Interface system, permits alternative paths of instruction both within a Module ((a, b) and between Modules (c, d).

While all Modules must be traversed, in a number of cases, the order in which they are encountered can be determined by the student. This approach, therefore, takes into account the fact that many intelligent students are capable of browsing through course materials. It is also the case that given this possibility when the student fails to meet subsets of objectives, the system is self-correcting and through remediation adjusts for his failure to meet requirements. Figure 4 illustrates the application of this framework to IMPACT's IDM developed for COBOL2.

Modular Course Structure



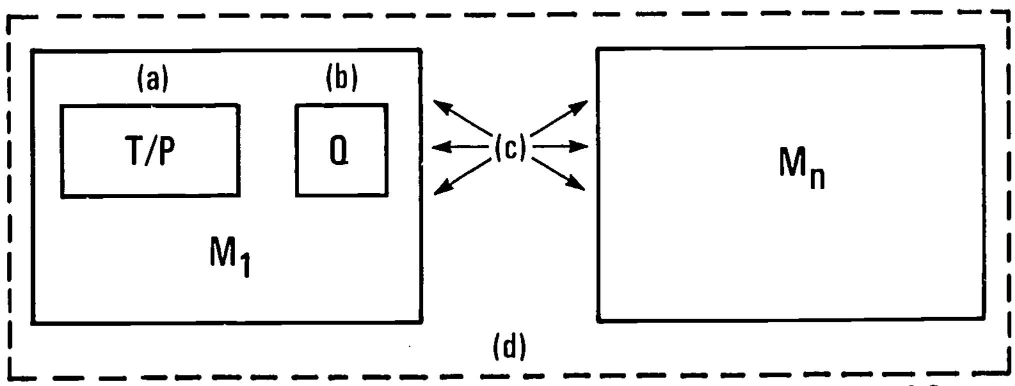
M = Smallest identifiable subset of Behavioral Objectives (Enabling and Terminal Objectives)

D = Major subset of Terminal Objectives

D_k

Figure 2

Framework for IDM Development: The Interface System



(a) Permits Alternative T/P Selection

(b) Permits Parallel Form Testing

(c) Permits Alternative Versions of Course Based on Topic Sequence and Form
- Acceleration
- Review
- Remediation

(d) Permits Student or System Control

Figure 3

Application of the Interface System:
IMPACT's IDM for COBOL2

Alternative T, P, Q: (a, b)	Alternate T, P, Q Forms Based on Structure of Intellect Factors, Student History, Confidence Behavior, and Student Performance Expectations
Course Versions and Sequencing: (c, d)	Partial Ordering of Modules
Skip-to-Quiz and Review	- Student Control within a Module
Recapitulation	- Student Control over Earlier Modular Review
Next	- Student Control in some cases of Next Topic
Remediation	- System Control Based on Failure to Meet Module Objectives

Figure 4

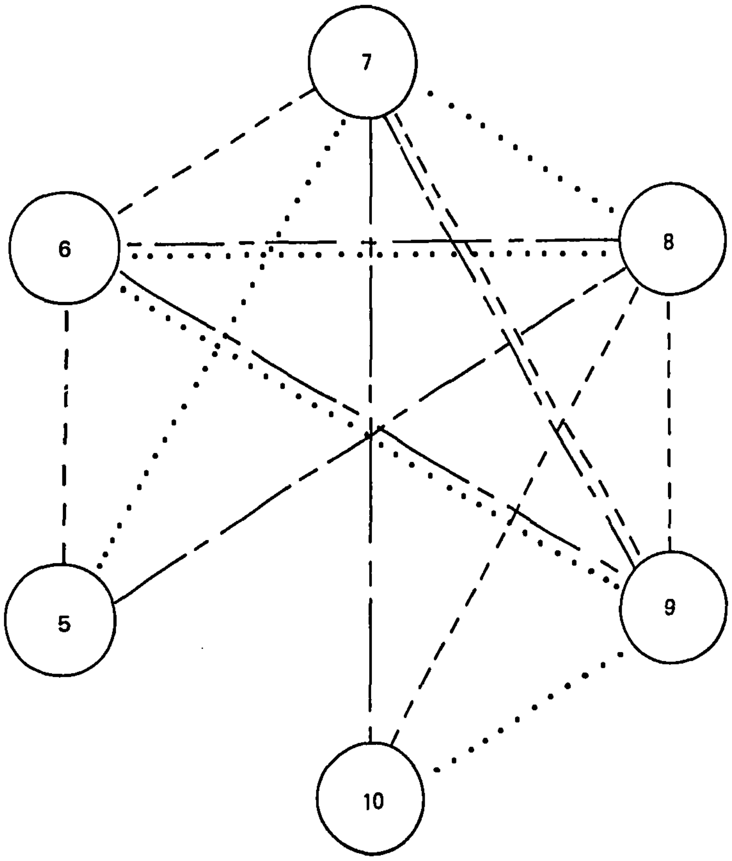
To illustrate further, Figure 5 shows three possible paths that a student might take in learning the content of Modules 5 through 10. In all, there are 12 possible paths, as listed below the figure. The allowable paths are determined from behavioral objectives as follows: When the behavioral objectives for each Module are developed, the prerequisite skills necessary to meet the objective are specified. The prerequisites are taught in earlier Modules. This framework allows any path between the Modules as long as no Module is entered before all of its prerequisites are satisfactorily completed.

At the end of each Module, there is a quiz to test the student for attainment of the behavioral objectives for that Module. The results of this testing are used for sequential instructional decision making. Although responses may be called for within a Module, their immediate purpose is to give the student practice as distinguished from the criterion and diagnostic testing purpose for responses at the end of a Module. These measures, while not directly involved in on-line decision making, do add to the data base for evaluating variations in instructional strategies.

Directions and Future Prospects for Subsystem Specifications

The Project IMPACT staff is presently developing design characteristics for second generation hardware and software. Heavier emphasis is being given to secondary visual displays and animation. Off-the-shelf components in a mini-computer framework combined with a larger host central processor will provide a basis for an implementable operational system. These off-the-shelf components use proved TV technology that has benefited from decades of investment in development, reliability testing, and production. Instructional usage can be optimized by proper allocation of processing requirements between the mini and the large Central Processing Unit (CPU) for various tasks. Looking further ahead, a display terminal capable of displaying 3-D, color and graphics, which was designed internally at HumRRO, is being breadboarded, as is a sound retrieval system. Practical advantages of such a capability relate, for example, to courses dealing with equipment where there is instructional enhancement by viewing this equipment from many different angles and from many different depths. Stated in another way, in a more general sense, the design capabilities will vastly extend the intelligence of the human instructor in such a configuration.

Alternate Inter-Module Paths



5 6 7 8 9	5 7 6 8 9
5 6 7 9 8	5 7 6 9 8
5 6 8 7 9	5 7 8 6 9
5 6 8 9 7	5 8 6 7 9
5 6 9 7 8	5 8 6 9 7
5 6 9 8 7	5 8 7 6 9

Figure 5

Our approach in developing the design of a configuration is based upon the requirements for decision making within an instructional system that incorporates the computer, peripherals, and software as the loci for these decisions. Stated another way, CAI configurations could be viewed in terms of the input, processing, and output requirements. To date, the emphasis in the field of CAI has been on input/output—display devices—to the virtual exclusion of an analytic approach to determining processing requirements. In one sense, this has reflected a realistic and appropriate concern with the price of student terminals, the largest multiplier of costs in a hardware subsystem. It is time to re-examine the CAI system architectural requirements not only as to available I/O hardware, but also with a new focus on the instructional decision-making requirements. The range of requirements determined by instructional strategies can be illustrated by two extremes: (a) the case of a simple, linear drill-and-practice exercise in arithmetic where the decision to be made by machine is simply whether the student's answer is "right" or "wrong," and (b) to present the next exercise. Contrast this with the decision-making requirements in a complex tutorial interaction such as described earlier in the

IMPACT IDM. The guiding premise for this analysis is that these decision functions can be allocated in a systematic fashion to different hardware components and varying complexities of software.

The goal of this analysis is to recommend a hardware-software subsystem that will be optimized not only on dependability (flexibility), storage, speed and dollar constraints, but also will fulfill perceived decision requirements for various kinds of instructional strategy research and instructional design. For large-scale operational system design, a trade-off will be required among the interacting dimensions of the computing resources: communications, storage, I/O capacities, information processing (decision making), and hardware/software components. For training system planners, a higher level decision guide should be shown to lend direction to potential purchases for near-term and long-term subsystems.

The framework for the current analysis is given in Figures 6 and 7. The system components at three loci are shown schematically in Figure 6. They represent the terminal, mini-computer, and central computer loci. The system functions to be allocated to these components are listed on the right, with emphasis on decision-making functions, since this is our major concern. The letters in parentheses show the alternatives for function allocation among the various system components.

CAI System Functions To Be Allocated at Various Architectural Loci

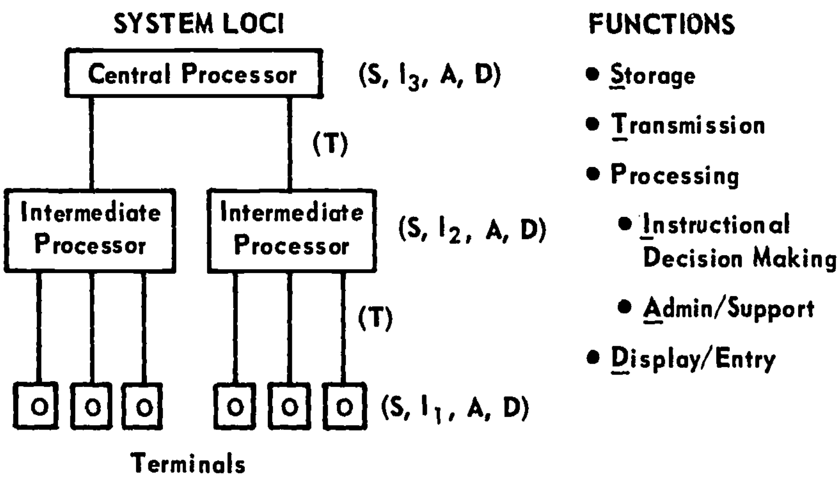


Figure 6

Locus of Instructional Decisions

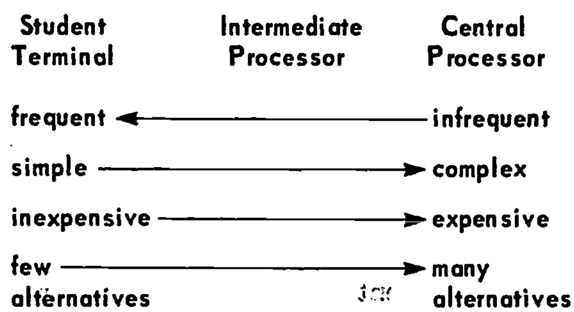


Figure 7

Figure 7 outlines factors to be analyzed when allocating the *decision-making* functions. *Cost*, *complexity*, and *frequency* of decision making are the dimensions shown here.

It is proposed that simple decisions can be handled most readily at the terminal; decisions of intermediate complexity (related to simple algorithms), within the structure of the mini-computer; and finally the most complex computational requirements, by the large central computer. The simple instructional decisions are also the most frequent, and the overall dimension of frequency suggests that the number of decisions of increasing complexity also occur rather infrequently.

It is interesting that the dollar costs for these decisions and their attendant computational requirements also increase as one moves from the terminal back to the large CPU. Clearly, the implications are to spend no more dollars than one has to for implementation of given instructional strategy. It can be stated, therefore, that with some instruction requiring simple procedural decisions to be made, no more than a simple, mini-computer subsystem, plus the terminal, perhaps with some disk storage, would be necessary. Another dimension that seems to be relevant to the decision-making framework is that of the distinction between software decision algorithms versus hard-wired, logic card capabilities. Here, too, the closer we get to a large CPU, the greater the requirement for software involvement for implementing these decision algorithms; conversely this is so with respect to the terminal.

In our current design for a second-generation hardware/software subsystem, we are including a number of off-the-shelf components with reliable, well-tested TV technology to include a flexible, versatile, interactive graphics terminal with expandable capabilities for color, voice, and 3-D possibilities. The terminal with its limited information processing capability will be linked to a mini-computer to accomplish more complex, less frequent decisions, as well as to a large host CPU to process the most complex instructional decisions. This design, therefore, includes a compatibility with the latest design concepts[1] that will provide an increase in the state-of-the-art capabilities for CAI architecture. This approach takes into account differing needs that require, in general, presenting a different stimulus to each student. Hardware that can only retrieve most images rather than logically construct images will be inadequate, not only because of the costs to store and retrieve such large repertoires of images, but because of the impossibility for authors to anticipate the entire set of images. Furthermore, these logically constructed images, in order to meet the demands of instructional strategies, need to have degrees of freedom such as varying color, 3-D, gray level, high resolution, and rapid updating for sequencing purposes.

The application of this overall approach will permit us to develop an optimization rule or algorithm for resource allocations within this environment so that examples of different kinds of tasks with different decision-making requirements can be identified and can provide base-line data for developing the optimal allocation of resources within the proposed system.

The IMPACT system is to be structured so that each terminal cluster has an independent, reserved processor—in fact, a mini-computer. Therefore, terminal clusters do not compete for processing from the peripheral processors in the IMPACT system. Furthermore, the dedicated processors in the proposed system can result in off-loading from the central processor. That is, the mini-computers can be programmed to provide information processing in a local loop. The central processor in the IMPACT system needs to be used only when the local processor needs computational or decision augmentation. Another case would be when information is required that is not directly available to the mini-computer.

[1] The design concepts were developed by Dr. Ronald J. Swallow, Systems Engineer with HumRRO's Division No. 1.

Such a configuration is an example or application of the approach noted for CAI system architecture—allocate decision making to the least costly computer resource that is capable of meeting response time requirements for given instructional tasks.

Immediate Implications for CONARC

While we are pursuing the completion of the design described, we can make interim recommendations for many levels of consideration, as follows:

(1) We feel that CONARC should keep options open with respect to hardware and software purchases. Premature decisions for an Army-wide operational configuration could cause "locking" into either a limited hardware approach (e.g., large central processing unit with remote terminal configuration) or into one that is fast becoming obsolescent (such as a first model prototype of a third-generation computer).

(2) CONARC should continue its excellent work on the emphasis of specifying training objectives in behavioral terms. The application of a systems engineering requirement will be of immeasurable value no matter what the ultimate decision is on CAI computer configuration.

(3) A coordinated framework should be established relating research and development efforts with a pilot operation system. This has already been initiated by the establishment of informal coordination between Fort Monmouth and HumRRO, as well as by preliminary steps taken with the U.S. Army Transportation School at Fort Eustis, Va. and HumRRO. As feasible, this relationship should be encouraged and expanded so that data base and capabilities of research, development, and operational outputs can mutually facilitate advancing CAI to a full-blown reliable and tested operational capability.

(4) Related to these recommendations, but a specific activity, is the necessity to identify and permit evaluation of various kinds of instructional strategies regardless of whether a computer is introduced into the instructional system. This will facilitate incorporating the computer either in a computer-managed framework or as a part of an adaptive, tutorial system whenever the conversion is made.

(5) CONARC needs to gain the cooperation of the various directorates within the Department of the Army for the purpose of developing a workable system for individualized personnel management. This should apply both to pre-training selection and post-training assignments.

Using the approach outlined, we will be able to deliver to the Army a set of guidelines for properly designed CAI hardware and software subsystems that can be implemented on a nationwide basis. A number of questions necessary for the Army to answer are related to the individualized assignment capability (first developed jointly by personnel from Project IMPACT and from Work Unit STOCK). There have to be operations research type models developed for determining density of student population, complexity of tasks, various demographic concerns of instructor-student ratio, as well as terrain characteristics (pertinent to adequate signal transmission), before a particular application of this approach can be applied to a specific locale for the Army within the United States.

In this "history" of IMPACT and its relevance to the training needs of the Army, I have mentioned some usable products already developed. With the approach to systems design as outlined, HumRRO will be able to deliver to the Army, specifications for appropriate design of CAI hardware and software subsystems usable for Army-wide implementation.

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13. ABSTRACT
With shrinking financial resources and a smaller, largely volunteer Army, demands made on personnel and the importance of each individual soldier will increase, posing difficult problems in training. The training must deal with widespread student differences, provide an increasing number of complex skills, and use an even smaller number of skilled instructors. Computer-administered instruction (CAI) is a most promising approach, if it is developed as a comprehensive and total system. The goal of Project IMPACT is to provide an effective, efficient, and economical CAI system in a total system framework. This paper reviews the (a) reasons for establishment of Project IMPACT, (b) nature of the project and its relevance to needs of the army, (c) reasons why the Army needs to develop its own capability in CAI, and (d) directions and prospects for delivery of specifications for an operational CAI system for the Army within the next two years.

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