THE OPERATION OF COMPUTER-MANAGED INSTRUCTION IN THE NAVY: CURRENT AND FUTURE PERSPECTIVES

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Introduction

The Navy CMI system represents the most outstanding large computer-based, individualized instructional system developed to date; an important achievement for which there are several reasons. First and foremost, there has been and continues to be *exemplary training effectiveness within* the system. The logistic achievement of a computer supporting in excess of 3,000 students represents a first in this field. A more dramatic achievement is the cost beneficial outcome -- a savings of $10.2 million during FY 75; a savings rarely found in the beginning life cycle of a training system. Finally, the Navy CMI system has institutionally integrated Navy technical training into common prac*tices and styles while achieving its own* unique benefits.

Current Outcomes

The development performance data yielded to date by the Navy CMI system provides a strong quantitative argument in its behalf. First the CMI system has yielded significant course reductions ranging from 24 to 80 percent with a mean *of 48.6 percent. This has yielded a $10.1* million saving in student salaries. Table 1 presents a comparison of the BE/E, AFUN, and ADJ course times under conventional and computer-managed instruction. Secondly, the effective reduction in on-board students has allowed for an associated reduction of 23 percent in instructional/support personnel which has yielded savings of $1.2 million. Table 2 presents the number of authorized and on-board instructor billets for FY 72-74 in the AFUN and ADJ schools of NATTC, Memphis. Third, the CMI *training approach yields significantly* better end of course performance levels while the attitudes of students tend to be more positive. The mean BE/E mastery performance levels and completion times for conventional instruction, IMI, and CMI groups are presented in Table 3. In turn, the CMI system tends to significantly lower the attrition rate, somewhere between 4.5 and 11.1 percent. This has yielded approximately $550,000 in savings for FY 75. Since NAS Memphis is the only user of CMI for the BE/E course up to January 1975, the attrition data for the last half of FY 74 compares instructor-managed instruction (IMI) at San Diego and Great Lakes, with CMI treatments at Memphis. Table 4 presents this attrition data by location, attrition type (academic vs. non-academic), and mental groups I - IV. Finally, the computer implementation, both as currently running and in terms of the acquisition of the Honeywell system for expansion, has yielded savings in both the competitive procurement itself and the potential for expanded capability. In terms of the institutional training processes, the CMI

Table 1

Mean Course Time Savings Via CMI

Course	Conventional Instruction Time	CMI Time	Percent Reduction
BE/E	210 hrs.	159.3 hrs.	24.1%
AFUN	180 hrs.	35.45 hrs.	80.31%
ADJ	198 hrs.	118.2 hrs.	31.0%
Mean Total	196 hrs.	104.3 hrs.	46.8%

Table 2

NUMBER OF INSTRUCTOR BILLETS FOR FY 72 - 74

Billet Description	FY 72	FY 73	FY 74
ADJ - NATTC Memphis			
Authorized	69	64 (7.3%)	55 (14.1%)
On-board	66	66 (0%)	55 (16.7%)
AFUN - NATTC Memphis			
Authorized	116	98 (15.5%)	77 (21.4%)
On-board	134	96 (28.4%)	92 (4.0%)

*Figures in parentheses indicate percent reduction from previous year.

Table 3

Mean BE/E Mastery Performance Levels and
Completion Times For Conventional Instruction,
IMI, and CMI Groups

Instructional Type	N	Mean Scores For 1st Pass on Final Comprehensive Test*	Mean Completion Times (Hours)
CI	50	79.30	214.68
IMI	50	77.69	163.62
CMI	1556	82.73	152.47

*100 = perfect score

Table 4

BE/E SCHOOL ATTRITION
(Jan-Jul 1974)

	Great Lakes IMI	Memphis CMI	San Diego IMI
Percent Flow (Sample Size)	2989	3210	2579
OVERALL ATTRITION	17.9*	6.8*	11.3*
School Academic Attrition	9.6	2.2	9.8
School Non-Academic Attrition	8.3	4.6	1.5
School MG I and II Attrition	5.7	3.5	3.8
School MG III Attrition	9.9	2.4	7.2
School MG IV Attrition	1.2	.4	.3
School MG Unknown Attrition	1.1	.5	.8

*All attrition statistics are percentages of the total student flow.

system has effectively integrated both personnel and operational procedures. For example, the learning center supervisors and ISD personnel, who are highly committed to CMI's implementation and operation, perceive its approach to individualizing the training process as most successful. The attitudes of the involved personnel are highly positive, thereby benefiting the system's effective implementation and success greatly.

The Navy system also represents an outstanding example of how R&D activity culminated in fruition of an actual training operation. The research climate, shared civilian and uniformed personnel, a commitment to sound training design, and an adaptive approach to CMI systems goals undoubtedly led it to achieve the R&D to operational cycles in less than a decade. In comparison with the University of Illinois PLATO system and the Air Force Advanced Instructional System, Navy CMI represents the largest of these approaches and seems a natural candidate for both its planned expansion and its further elaboration in the future. While each of these three computer-based systems has their own worthwhile unique purposes, goals, and implementation characteristics, the Navy CMI system is yielding performance and cost benefits that are especially attractive during the mid '70's.

Plans For Enhancement

Given the success to date of the Navy CMI system in terms of achieving its objectives and its cost/beneficial outcomes, one could raise the question, "Why implement new alternatives?" There are two very persuasive reasons: first, technological systems tend to overachieve themselves at times. For those that are creating a major breakthrough, even further benefits can be achieved by appropriate enhancements of their approach and the domain of activities they enter. For Navy CMI this would indicate a further investigation of not only enhancing instructional strategies, but also the kind and type of course for which it supports. Secondly, it is common for technologically-based systems to undergo repeated cycling between research and on-going operations. The research and development activities act as a stimulus to further fine-tune the CMI systems. Given the amount of DOD money being currently invested in basic research (6.1) and advanced development (6.2), especially in the area of computer-based training, it would seem ill advised not to continually survey the outcomes of this effort and consider possible incorporation within the Navy CMI system. Obviously, the consideration of these alternatives should meet an appropriate set of criteria.

While the consideration of criteria for preliminary implementation of a new instructional strategy or associated training technique within the CMI system requires extensive analysis, assessment, and policy determination as to their impact on the on-going operation, the following criteria seem appropriate for consideration:

1. The new training alternatives should represent a significant contribution to the reduction in cost and the enhancement of the training outcomes for the CMI system.

2. The new alternatives should not disturb the on-going operation or make excessive modification requirements, but rather should fit into the on-going operation in the form of an extension or further enhancement of the on-going computing system.

3. The new training alternatives should have a sound experimental base; therefore, the ties back to the Navy's basic research capability should be obvious and direct.

4. The new alternatives should be consistent with and supportive of the mission of Navy training.

Given these or more refined criteria, two major trends of research prototypes are appropriate for consideration by the Navy CMI system. The first of these relates to the enhancement of the instructional strategy process. The second relates to the supporting and institutional ISD process and personnel. Each of these shall be considered in turn.

For each considered trend (instructional strategies and ISD processes), there are interrelationships at each stage and accumulatively. For example, each stage assumes the existence of its parallel element and shares data and findings. Secondly, each will require computer software enhancement that will support each in a common manner. Finally, the eight considered R&D elements mutually support each other in a fashion that should lead to a vastly enhanced CMI system. (Obviously, each considered R&D element qualifies according to the four above criteria; each would require planning and detailed designs to be implemented.) This process is illustrated in Figure 1.

Instructional Strategies

Instructional strategies can be defined as the development of training resources so as to appropriately create a sequence and environment for a given student so that his learning and performance is maximized. From this frame of reference, there are four obvious stages through which the CMI system could appropriately develop in terms of its enhancement and growing sophistication. These are as follows: (1) operational research to enhance individualized learning, (2) adaptive testing to improve the measurement process while reducing testing time, (3) adaptive management of the system so as to dynamically match resources with student requirements, and (4) complex training through simulation. Each of these will be discussed in turn.

1. Operational Research to Enhance Individualized Learning. The application of operational research techniques plus the development of operational learning feedback mechanisms have proven powerful in both management and training systems. While the CMI system has the existing capabilities to provide masses of data potentially useful to LSC's course managers, and instructional designers, there appears

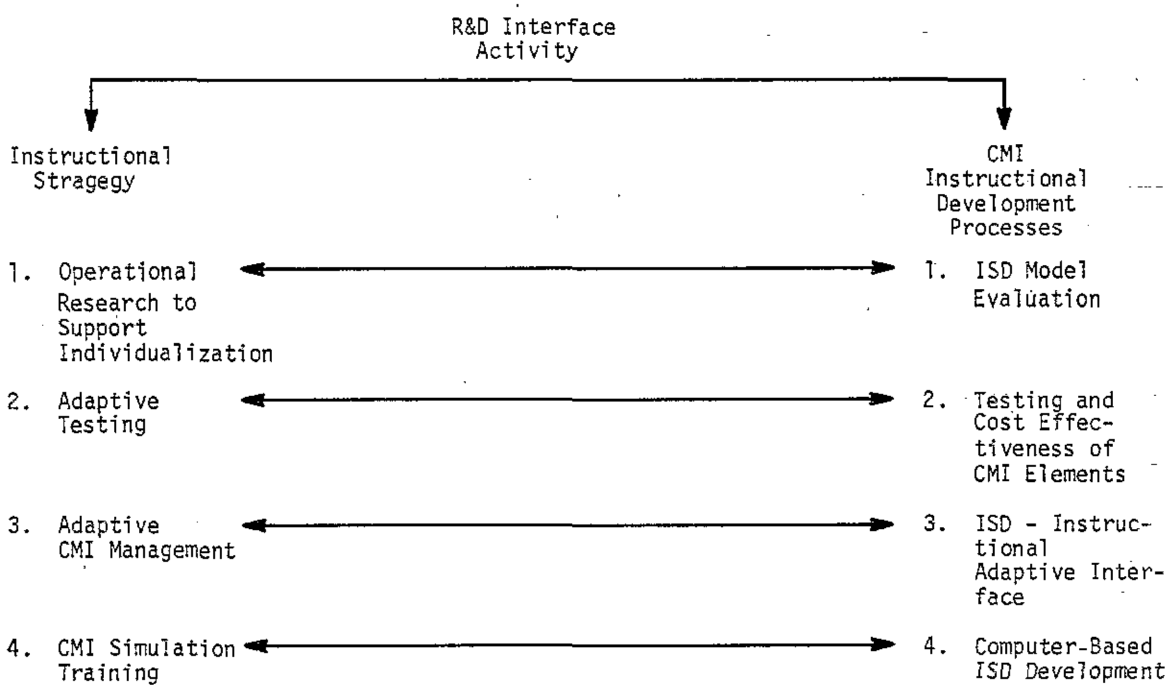

Figure 1. The Interface of R&D with the CMI System

to be an unfortunate limitation in the instructional diagnostic reporting capability. This deficiency may be largely due to an emphasis on the individual student in his everyday instructional progress to the exclusion of learning characteristics of groups of students within the system. Thus, the available data is not systematically stored or organized so that it may be retrieved with its full interrelationships and implications. For example, performance times are accessible, but without reference to the categories of students or specific segments of content. While this data is available on an individual basis, no provision has been made for its group of system implications so as to monitor group progress and fluctuations over periods of time. Moreover, the current data does not adequately address the characteristics of levels of difficulty of lesson material, appropriate assignment of media, and the effects of remediation. Therefore, an operational research thrust should be pursued so that on the one hand attempts to gain more information on groups of students can be achieved, while at the same time looking at implications for the significant instructional strategy elements. This is the main focus of this initial stage.

Within the DOD training research world, there is extensive evidence to indicate that assessment of functional reading, learning styles, instructional adaptation indices, information processing indices, and incentives can provide significant insights into individual and group behaviors, both from a current progress and predictive point of view. It is proposed that these existing tests be given to sufficient size sample of Navy students and then be related to data concerning the level of learning difficulty, the assignment of media, and remediation. Simply, an individual by group by instructional strategy data cube should be formed which shall allow for better insight into the assignment of students, rather than continuing the voluntary student self-selection strategy currently found in Navy CMI. Such a system of assignment has yielded enhanced performance in the 10 to 20 percent range. While there is limited evidence concerning reductions in course learning time, it is an obvious relationship and one can anticipate at least a five percent time savings. Therefore, this operational research stage appears to have high benefits and should be aggressively pursued.

2. Adaptive Testing to Improve the Measurement Process While Reducing Testing Time. One of the key components within Navy CMI is the systems testing of the students' performance upon completion of each module. The time devoted to this activity varies between 18 and 25 percent of the total time spent by a student in a course. Given such an extensive commitment to measurement, the application of adaptive testing techniques appears appropriate. Adaptive testing, especially when implemented over an individual terminal, has yielded better than 50% reduction in testing time. Given the nature of the equipment, it is proposed that a pilot study investigate the application of adaptive testing techniques to the existing batch oriented CMI terminals as opposed to individual CRT terminals. (It should be noted that no enhancement of equipment would be required in order to pursue such a pilot study.) If it can be documented that batch-adaptive testing is equivalently effective in terms of time savings, such a procedure could be implemented with little or no cost to the current system. Such an assertion as this is possible in that the actual procedure for assigning tests can be adjusted to adaptive techniques with little effort.

3. Adaptive Management of the System so as to Dynamically Match Resources with Student Requirements. Adaptive management refers to the two-fold application of optimal allocation of resources, such as learning center supervisors' time or laboratory equipment, according to the individual and group parameters found for the students. At the present time, the Navy CMI system presents the same prescription to all students, given their equivalent progress through the course. It is proposed that further individualization could take place, while preliminary research is still underway (NAVPERSRANDCEN/MSU Study of Adaptive Instruction). In addition, a dynamic scheduler for critically costly resources, be these human instructors or simulators, can insure better utilization of these resources within the Navy training environment. It is on this basis that it is recommended that the Navy CMI system pursue this line of development along with the other two branches of the service. (This is an active part of the Air Force AIS program and the Army CTS System.)

4. Complex Training Through Simulation. During the past decade and one-half computer-driven simulators have become a common phenomena in all forms of military training. Unfortunately, the cost of a weapons system-like simulator, in many cases, exceeds that of the weapons system itself. Therefore, it seems appropriate to enhance the Navy CMI system in the long term so as to operationalize those aspects of simulated training appropriate as a precursor or follow-up to the availability of the actual equipment. Such simulated training on the S-3A or in the preliminary TRIDENT training study indicates the power and cost effectiveness of such a CBI approach. Given that this is the fourth stage in the trend, it is anticipated that further results over the next two or three years will contribute significantly so that once the Navy CMI system embarks on such an endeavor, it will proceed on the firmest basis upon training research findings.

Institutional ISD Processes

The interrelationships between CMI and Instructional Systems Development (ISD) processes are both extensive and in many respects undocumented and/or unexplored. The goal of this second trend of research will be the clarification and the empirical evaluation of the ISD processes as they interface with CMI requirements. This effort should lead to a better definition of the actual interface requirements and provide clearer cost effective techniques and methodologies for facilitating this critical developmental area. Given an understanding of the current CMI system and its likely developments in the future, the following four stages are offered within this ISD developmental trend as follows:

1. ISD model evaluation for CMI requirements.
2. Testing of the cost effectiveness of CMI elements.
3. Adaptive interface of the ISD - instructional process.
4. Computer-based ISD development.

It should be pointed out again that each of these stages not only contribute sequentially, but are interfaced with the instructional strategy for parallel stages; that is, the operational research will feed in directly to the ISD model evaluation and CMI requirements. In turn, adaptive testing provides the basis for fine-grained analysis of the CMI cost effectiveness. Adaptive management leads directly into a consideration of adaptive ISD instructional interfacing. Finally, training simulations are of the same complexity and sophistication as computer-based ISD development.

ISD Model Evaluation for CMI Requirements

During the last five years, Navy training has created and propagated significantly new instructional systems development models for the creation and updating of curriculum and associated training materials. These models profited extensively from prior research work in task analysis. From the beginning the Navy CMI project has interfaced and utilized Navy ISD personnel for the conversion and the development of CMI courses. The requirement for building a bigger pool of expert manpower is obvious and critical. At the same time ISD models have remained relatively unevaluated in terms of each component's output. (It should be noted that the overall effect of the ISD model process has proven to be highly effective.) When two major systems (namely, ISD and CMI) are required to interface, it seems appropriate to evaluate the ISD model in terms of its contribution to this CMI effort. The focus of this first stage of research study is to empirically document the contributions of Navy technical training ISD and courses as they undergo conversion. This documentation will both be in terms of the manpower employed, the procedures utilized, and their ultimate effectiveness within the CMI operation. Utilizing data from the operational research stage in the instructional strategy trend as well as specially collected data, one can anticipate that those ISD components most critical to the CMI requirements can be identified.

Testing of the Cost Effectiveness of CMI Elements

The cost effectiveness of Navy CMI is outstanding. Unfortunately, the contribution of various components remains to be established. For example, it is the ISD process that is contributing the most to this effectiveness, or rather is it the testing and prescriptive process? One hears many advocates of the student tracking and project incentive techniques as being at the heart of the impact of the CMI system. The thrust of this endeavor shall be to utilize data from the operational research and the adaptive testing as ways of assessing the effectiveness and contribution of each of the CMI elements. Critical base-line data shall be utilized as the instructional strategies evolve so that component effects can be isolated. It will also be important in terms of the relationship between the ISD personnel and the instructional personnel, our next research stage.

Adaptive Interfacing of the ISD Instructional Process

Unfortunately, the interrelationships between the specific functions and relationships of both the Learning Center Supervisors and the ISD personnel have been informal. The exact communication and purpose of the communication is yet to be documented. For example, should the ISD personnel be preparing materials to be utilized by the Learning Center Supervisors as they may undertake new functional roles. If the LCS's were given even broader alternatives for remedial tutoring, personal counseling, and application of human resource concepts within the context of technical training, what types of materials should be under preparation by the ISD people? In essence, the focus of this study is to identify appropriate interrelationships between ISD personnel and the Learning Center Supervisors. This mutual facilitating interrelationship will be tested out by having new functions evolve for selective, lead LCS's and evaluated in terms of the support of the ISD group as well as the LCS's ability to accept and expand their functions. The intent is not to redefine roles but to enhance them. This is predicated on the fact that each of the groups expressed to varying degrees, the LCS's more so, the ISD personnel less so, the worth of their significance within their activities. By enhancing their roles and applying a proper utilization of leadership management and techniques, one can anticipate that significant increases in effectiveness should occur.

Computer-Based ISD Developments

During the past decade, the utilization of a computer for curriculum development has been proposed by a number of leaders and groups. The preliminary attempts at such places as Florida State University and Stanford University have proven to be quite promising. Within the DOD community this activity has been limitedly explored at NPRDC. Therefore, it seems most appropriate to propose it as a culminating sophistication for the Navy CMI ISD trend. What is being proposed is the utilization of computer terminals for the actual planning, authoring, pilot testing, formative evaluation of materials, prior to their use in more conventional off-line purposes within CMI. The argument put forth is that this should provide for a faster development of materials as well as more detailed formative evaluational documentation and substantiation. If this is really the case, this could become a highly important function of the Navy CMI system and should not be considered supplemental or supportive in nature. Curriculum creation (especially revisions) is an extremely costly process. If computer-based developments could facilitate both the timing and cost aspects, this would be a major breakthrough in the DOD training world.

Conclusions

1. Given the R&D and extensive, successful, growth of the Navy CMI system, the further enhancement by proven research prototypes and findings should be pursued so as to broaden the impact of individualized training.

2. The selection and implementation of R&D prototypes should be based on rigorous criteria and high likelihood of enhancing the cost effectiveness of the system.

3. The considered elements of instructional strategies and Instructional System Development activities appear to be the most likely candidates for implementation.

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