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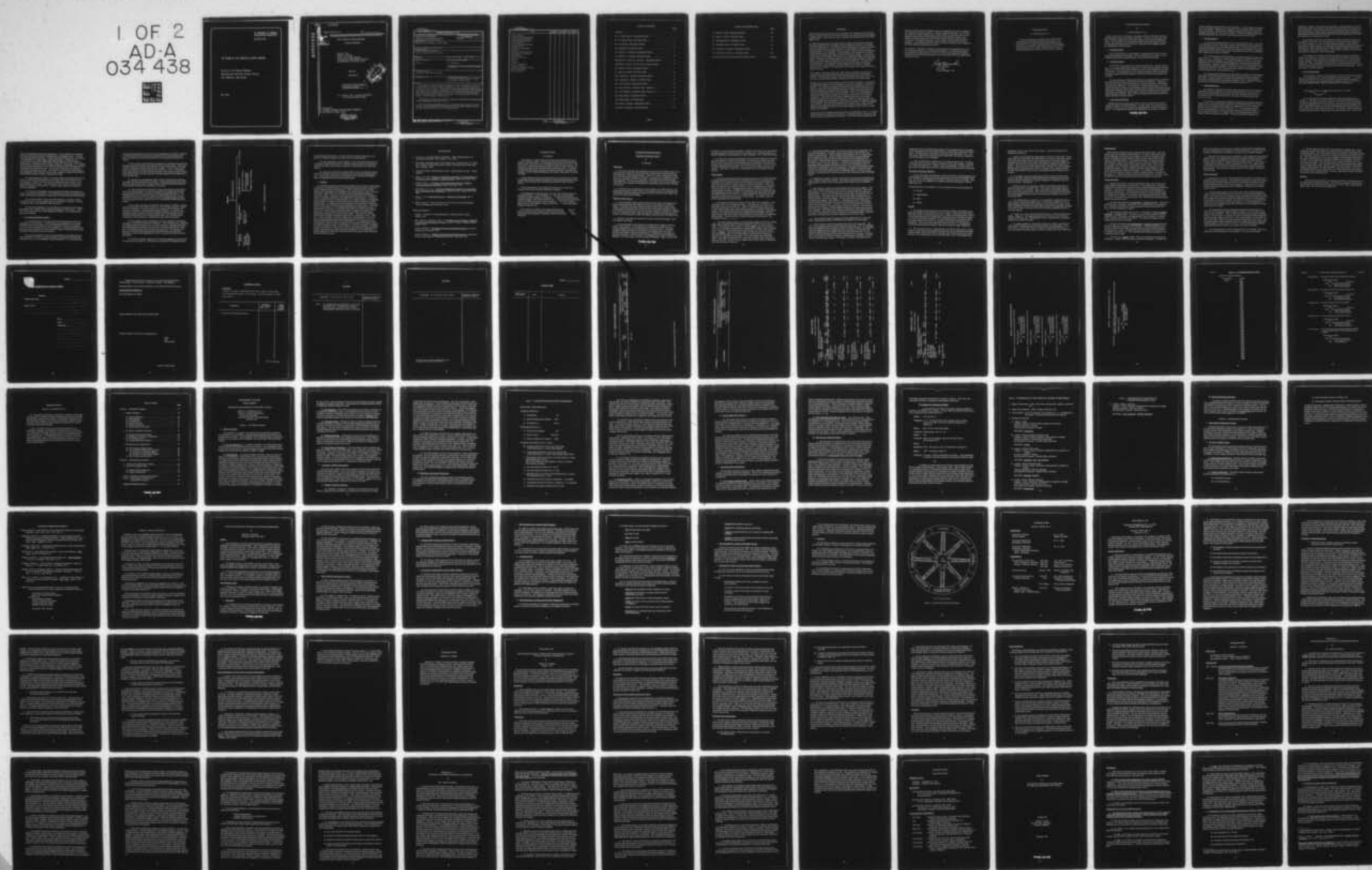

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THE FUTURE OF THE COMPUTER IN ARMY TRAINING

OFFICE OF THE PRODUCT MANAGER
COMPUTERIZED TRAINING SYSTEMS PROJECT
FORT MONMOUTH, NEW JERSEY

MAY 1975

Report CTS-TR-75-3

AD________________

THE FUTURE OF THE COMPUTER IN ARMY TRAINING

Joseph J. Rich
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Office of the Product Manager
Computerized Training Systems Project
Fort Monmouth, New Jersey 07703

May 1975

Final Report

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Army Research Institute (ARI)

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13. ABSTRACT

The invitation to submit comments was extended to a Panel of Consultants on a site visit and conference at Fort Gordon, Georgia, December 7-8, 1974. The primary objectives of the conference was to construct a report which will define medium- and long-range plans for improving the Army's Computer Training System. The ultimate objective centers on investigating means by which progress from the current state-of-the-art in training technology to improved Army instructional systems can be realized. Each individual consultant was required to contribute a paper to the final report.

The purpose of this report is to compile the comments on Computerized Training Systems (CTS) in compliance with Task Order 75-129.

This report contains biographical sketches, general impressions, answers to selected questions, and recommendations for future medium- and long-range development of computerized training systems in the US Army Training System.

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Simulators						
Computer Assisted Instruction						
Technological Developments						
Mincomputers						
Solid State Memories						
Hardware						
Software						
Terminal						
Army Training System						
Display Technology						
Computer Supported Instruction						
Medium Range Plans						
Long Range Plans						

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FOREWORD

This technical report is the result of a site visit by the consultants to Fort Gordon, Georgia, location of the Army's Project ABACUS, a 128 terminal multiminicomputer training system. This is the only major computerized training project in the United States Army.

In reading these comments the reader should be aware of the fact that at that time the system installed on site consisted of only one display controller, 32 terminals and very limited software. The ultimate system will consist of 4 display controllers, a systems controller, a data base controller, 128 terminals and much more extensive software. This limitation was not, however, critical to the accomplishment of the objectives of the conference. The participants were requested to comment primarily on the long-range implication and on the current concept. As can be seen by the contents of this report, the reactions were enthusiastic and the remarks quite candid. To assist in the implementation of some of the ideas expressed, I asked my staff to prepare an executive summary of the recommendations. The result was a 24 page document. The message in that summary came through loud and clear. The Army must remain flexible in all areas whether it be hardware, software, courseware or evaluation. At some point in time, however, the moment of decision must be reached.

With respect to hardware, there was a wide variety of opinions varying from the current trend toward stand-alone terminals to a preference for large regional systems. The concensus, however, was that each requirement must be met on its own value and that systems should be tailored to meet the real training needs.

Software was a major concern among the majority of the consultants. In particular, the applications software, and the language to be used for authoring was subject to question. This matter has already been addressed at the Department of the Army level, our needs have been recognized and are being taken into consideration by a special working group on higher-order languages. When considering courseware, we must place the subject into its proper context. None of our representatives would recommend that the computer be utilized as the sole means of presenting instruction. The proper mix of computer managed instruction, and computer assisted instruction, was a controversial topic. Further, experiments into such areas as multiple-track strategies, learner-control courses, and confidence testing, were suggested. The need for experimentation in these areas is readily recognized; however, this would cause undue burden on the evaluation of the current system. Rather than dropping the ideas we are currently seeking for other means of testing these innovative ideas.

It was in the area of evaluation that the majority of the discussion arose. To properly determine where we should go in the future, it is essential that the evaluation of the current project be accepted by all concerned. There was unanimous agreement that the plan as written need be modified to take into consideration the shift in emphasis from computer assisted instruction to computer managed instruction. As a result, this office has already embarked upon a major project in cooperation with the Army Research Institute and the Advanced Research Project Agency to outline a very definitive plan for evaluating not only Project ABACUS but other ongoing projects in the field. This effort represents the major tangible results of the conference. Hopefully, the resulting benefits will impact not only on the military but on academia and in the industrial training world as well.

In conclusion, I would like to express my appreciation to the representatives of the Army Research Institute for coordinating the conference; to ARPA for assisting in the sponsorship; to the members of my own staff from the Computerized Training Systems for their efforts and naturally to Fort Gordon and the US Army Signal School for acting as hosts.

G. B. Howard

G. B. HOWARD
COL, SigC
Product Manager, CTS

Biographical Sketch

O. Dennis Barnes Ph. D.

Currently Chairman of the Department of Instructional Technology at the Rochester Institute of Technology. Previously Director of Curriculum Development and Evaluation and Director of Computer Assisted Instruction for the National Technical Institute for the Deaf. Holds the Ph. D. in Instructional Technology from the University of Southern California.

A Training Management System

by

O. Dennis Barnes, Ph. D.

After a site-visit to Fort Gordon, conversation with the CTS staff, interaction with the project civilian and military consultants, a review of the literature of the CTS, and at the request of the CTS project manager this paper is herewith submitted. The first section is concerned with observations regarding the CTS project and the second (and Primary) section is concerned with a suggested system for managing the training process.

a. CTS Observations

The CTS staff seems to be enthusiastic, committed to the project, and concerned that the project will succeed. The two primary areas of concern are the evaluation design and the generalizability of the instructional strategy.

b. Evaluation Design

(1) Scriven[1] is attributed with the notion of formative vs. summative evaluation. It is readily apparent that members of the CTS staff are familiar with these notions and, at least in the Basic Electronics course, have applied these two types of evaluation. It is suggested that in the evaluation design for CTS two additional evaluation components be well specified: student performance and program performance.

(2) The evaluation of "student performance" is an analysis of the parameters associated with the student's acquisition of the desired behaviors. These parameters include length of time for acquisition, degree of acquisition, and attitudes associated with acquisition. The evaluation of "program performance" is an analysis of the degree to which the instructional program elicited the desired behavior. Parameters associated with program performance are efficiency of stimulus frames, optimization of sequencing, and the degree to which skill performance is attributable to program strategies. Both student and program performance should be examined formatively and summatively.

c. Instructional Strategies

Although CTS has an instructional model it tends to limit the way in which a student can acquire the desired behavior. In other words, for any given set of objectives, there is only one instructional technique used to elicit the desired behavior. It is suggested that flexibility be designed into the program to examine

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various strategies associated with a set of objectives. In a CAI context, this would mean, for example, designing a drill and practice and, perhaps a tutorial strategy for a given problem. Data could be collected to determine the general nature of a strategy which works for a given type of student. The work in Cognitive Style Mapping has applicability here in terms of describing student learning styles[2].

d. Training Defined

(1) The most intriguing notions to me to result from the recent on-site visit to the CTS Project were the statements made by Colonel Howard and summarized in the discussion guide for the training working group: "The current thrust of Army thinking and planning in general is to bring about significant increments in training proficiency for a given time period and/or to bring about a given level of proficiency with a significant decrease in training"[3].

(2) For the purposes of this discussion, the word training will be used in its usual sense, i.e., the process by which a desired behavior is elicited from an individual or a group of individuals. The product of training, however, will herein be defined not only as the required technical behaviors, but also communication and social behaviors. Explicit in these two definitions is the notion that training can be concerned with eliciting from either an individual or group, communication, social, and technical behaviors. In the usual sense, these behaviors are determined by a careful analysis of the requirements of a job.

(3) Communication behaviors deal with effective transmission of information. Social behaviors deal with successful interactions between persons or machines or vice-versa. Technical behaviors combine communications and social behaviors and deal with requirements for successful completion of a job. Technical behaviors are primarily concerned with cognitive and psychmotor behavior.[4, 5]

e. Establishing Needs

(1) In order to determine jobs which require training, at least the following parameters should be examined: 1) the task to be performed by a person or persons; 2) the interrelatedness of these tasks with other job tasks; and 3) the need for persons to perform these tasks for the short term (1-3 years) and the long term (3-7 years).

(2) The tasks to be performed should be analyzed by describing the communications, social, and technical skills required for successful performance of the job. At least one way of examining these skills is to determine for each the cognitive, affective, and psychomotor skill requirements.[4, 5, 6] A determination should also be made regarding the number of persons required to perform the tasks. If only one person is required e.g. typing a letter, the training process need only concern itself with training an individual. If several persons are required, e.g.

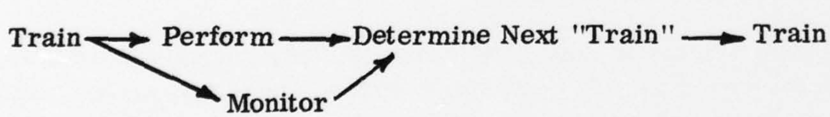
repairing a jet engine, then a team must be trained. The group dynamic or social skills will be much more complex in the latter than in the former case and will require identification. The last major function of establishing needs is the determination of the hierachy of skills which will effect the desired terminal performance.[7] This hierarchy should describe those skills which are prerequisite to the successful performance of the specified set of tasks.

(3) Very few if any jobs are performed in isolation without the influence of the products of other jobs. The team that repair a jet engine relies on other jobs for a host of results, e.g. data regarding engine performance, repair supplies generated by a supply systems, or performance specifications provided by engineers. Those jobs on which a specified job is dependent should be identified and the products defined. Without this information, a job for which a person or team is being trained can fail because of a lack of information.

(4) Obviously if a particular job after two years will require a 50 percent reduction in man-power, the need for a training program should be seriously questioned. Perhaps the best example of this phenomena occurs with a major technological innovation. The classic example would be the shift from vacuum tubes to transistors. Those responsible for training must provide themselves with a mechanism for determining not only the currency of the job skill requirements as well as the number of workers required.

f. On-the-Job Training

(1) Stokes says, "Most of the training that is done in America is done on the job. The immediate goal of on-the-job training is to develop a skill .... Actually performing the work is the only way a trainee can get the necessary practice.... The key to planning (on-the-job) training is the analysis of the job." [8, pp 54 & 55] The model presented below, might be considered an on-the-job model.



(2) In this model the job to be performed is noted by the appearance of "perform". Note that if a hierarchy of skills has been determined the individual or team will only perform part of the total job. The total set of job related tasks are only accomplished after a series of intermixed training and performance functions. Each "train" function is concerned with eliciting only certain behaviors of the total job; not the entire skill set of the job. The "perform" function should not simply be practice effects, although they closely approximate this. They in fact

should be integrated with actual job experiences. This is possible if an identified job and its training component are considered as an integrated system. Consider for example secretarial training. It seems theoretically feasible for a set of skills to be identified, e.g. filing, typing, answering the phone, transcribing, etc. Assume that the hierarchy of these skills would progress from low to high in the following way: answering the phone, filing, typing, and transcribing. The "training" process would first develop in an individual the ability to answer the phone properly. Conceivably this would take an hour. For the next several hours the individual would answer the phone on-the-job. The process of "monitoring" would determine the acceptability of the individual's performance, diagnose strength and weaknesses, and prescribe remedial training or logical advancement.

(3) The branch from "perform" to the next "train" is obviously linear for the trainee. Each new training function for each trainee will follow a sequential and linear pattern. However, from an overall training system point of view, the sequence process is non-linear. This becomes clear if a "monitor" function is defined by the following sub-processes: 1) observe performance and 2) determine level of acceptability.

(4) The level of acceptability will have been determined as an integral component of the behavior specification. The "determine next train" functional decisions process will have been specified as integral part of the skill hierarchy determination.

(5) Given this model, it can be seen that training is a continuous activity conducted in concert with the requirements and expectations of the jobs. Training as suggested here is not considered a discrete activity.

(6) Given this proposition, it is not difficult to see that the "train" function diminishes as the "monitor" function indicates acceptable "performance". Therefore, the two functions which remain ongoing and dynamic, are the performance and monitor functions.

g. A Training Management System

(1) A training system as described above can only perform as well as its management system performs. At least two premises suggested above should be considered major: 1) the definition of job-related skills in terms of communication, social, and technical skills and 2) the integration of training and performance. The latter point is possible only if the duration of trainee or teams productivity and training are integrated into one major system.

(2) A job and training for a job can be considered an interrelated process. This is feasible if a trainee's or team of trainees' performance is systematically examined by means of a well designed evaluation procedure. The training process

would be discontinued when the overall level of acceptability is achieved. Similarly, it would be initiated when an upward or horizontal move is deemed appropriate. Such a training process would be feasible given the organizational structure on page 10.

(3) The research section would be responsible for identifying and answering problems specifically related to the efficiency of the training process. This group would be an autonomous group reporting to the manager. The job analysis section would be responsible for determining the communications, social, and technical skills requirements of the jobs; determining the short and long term worker requirements; determining the job skill hierarchy; and determining the interrelatedness of a job with other jobs.

(4) The personnel management system would be responsible for ensuring the proper selection and placement of trainees. This section would obtain concrete data from the training division evaluation section in determining career paths and job performance for each of the personnel in its control.

(5) The training division would have overall responsibility for the development of the training system. It would be responsible for training those trainees and teams which have been selected by the personnel management system. The training division is not limited to training in a discrete period of time. It is responsible for training over a continuous period of time depending upon the nature of the training task and the amount and the level of performance obtained from the trainees.

(6) The training division is divided into three sections: evaluation, training system technologists, and materials producers. The evaluation section is responsible for examining on a unit by unit basis the performance of the trainees; determining, according to a predetermined sequence algorithm, the sequence that individual and team trainees will proceed through the training program, and examining the performance of the training program itself, e.g. the effectiveness of materials, and the efficiency of administrative and monitoring systems.

(7) The training systems technologists section is composed of what might commonly be considered instructional developers. These individuals are responsible for validating needs determined by the job analysis section, specifying the terminal performance objectives expected of the trainees, determining appropriate stragegies, and implementing and monitoring the training system. The materials producers are concerned with producing audiovisual and instructional materials. This section would include photographers as well as computer assisted instruction specialists.

(8) The fourth and final component of the training management system would be that of the job co-ordinator. This section is the team which manages the actual

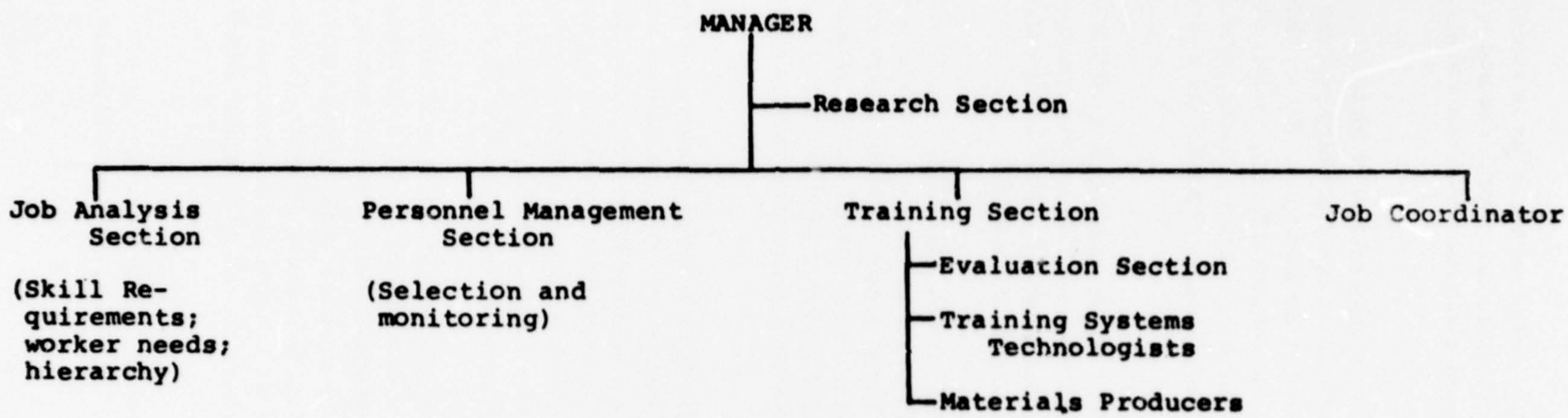


Figure 1. Organizational structure.

job performance requirements. In the secretarial example stated earlier, the function co-ordinator might be the supervisor of a secretarial pool.

(9) This management system suggests, in part, that training should not be considered a discrete activity but as a continuous activity based on a hierarchy of skills and the ability of the trainees to perform as determined by the monitoring function.

(10) One way of examining the effectiveness of such a management system would be to identify one job area in which the Army has extensive training experience. This job area would then be reorganized in such a way that the trainees would be integrated with the actual job requirements.

h. Summary

The assumption made for the discussion presented above is that the responsibility of training is to modify the behavior of individuals who are expected to perform on jobs at acceptable levels of performance. Jobs are defined in terms of tasks. Tasks in turn are defined as an identifiable set of communication, social, and technical skills. These skills, it is assumed, can be analyzed and ordered into a hierarchy of skills. The lowest on the hierarchy being required to be obtained in order for successful acquisition of the highest skill in the hierarchy. In order to modify a trainee or team of trainees behavior in an efficient manner it is suggested that the function of training be interrelated with the actual performance of newly acquired skills. In conjunction with the performance of these skills a monitoring function occurs which determines the acceptability of the performance. In the case where the performance is not acceptable the individual is sequenced to either remedial training procedures or recycled through previously experienced training procedures. In the event that the performance is acceptable the individual is appropriately sequenced to the next training module. The total set of training performance and monitoring functions need not be in a sequential manner. They can, in fact, be parallel. In order to effect such a training pattern, it is necessary to manage job performance and training expectations in such a way as to efficiently and effectively obtain the desired behavior. An organizational system is suggested in which four major components are considered: job analysis section, personnel management system, training division, and job co-ordinator. In addition to these four sections, a research arm which is quasi autonomous examines fundamental research questions regarding the generalizability of the training areas. A specific suggestion is made that a carefully selected job area be used to determine the effect of such a system.

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Biographical Sketch

Jan Danford

Jan Danford is currently Director of Curriculum and Instruction at the Capital Area Career Center. She has directed a special curriculum project that has been a pace setter both in Michigan and the country as a whole. The project is a curriculum system that allows all students to learn and move individually through a prescribed performance based curriculum. It is based on industrial task analysis utilizing the computer to analyze, prescribe and schedule, for each student depended upon the student's assessment of interest and needs.

Several special projects involving evaluation and curriculum for the disadvantaged and special education students are also being developed and implemented. Some materials are presently being tested and others will be in 1975-76.

Prior to this position, she worked out of the Governor's office as a Technical Advisor for Economic Opportunity Programs.

She graduated from Michigan State University with a Masters degree in Vocational Education. Upon completion of college, she was employed by Lansing Community College as an instructor in a Manpower Development and Training Program. She was then placed in charge of job placement and development for two MDTA programs, one in Lansing, the other in Mt. Pleasant. Before moving to the Governor's office, she was Director of the same MDTA program for about a year.

She is also the co-author of two published professional documents - A Guide to Community Action Agency Board Training for Improved Agency Performance and Applying the Cooperative Plan of Instruction to Manpower Programs.

Computerized Training Systems

Consultant Conference Report

by

Jan Danford

Intoduction

a. This report will deal with essentially three areas and will address them in the following order: CMI-CAI and Task Analysis, student-trainee needs assessment, and formatting of instructional packages. While it is virtually impossible to speak to any one area without touching on the others, or keep from overlapping into areas that cannot be dealt with in full in this paper, the attempt will be made to handle each separately. The order of presentation is also vital in that one is the outgrowth of the other and the quality and completeness is dependent upon the kind of job done at every step.

b. The writer chose to address these areas because of a background both in the developmental aspects of each as well as two and one-half years of implementation. The direction and recommendations made are based on what was seen, heard, and read and are presented accordingly.

CMI/CAI--Task Analysis

a. It was expressed verbally and is obvious from the state of development and the prevailing atmosphere that ABACUS is torn as to the direction it should be taking. To date they have dealt with CAI but have recently seen a need for CMI. I totally support this position and further feel that CAI should be thought of as only one possible instructional tool in an entire systems approach to instruction. ABACUS has, or is, backing into CMI. Since the same kind of analysis and preparation that is used in CAI is necessary for CMI, the change in direction will not be that drastic.

b. However, from what was observed, the writer feels that the quality, depth, and emphasis will change.

c. Several individuals at Fort Gordon were talked with in regard to what was termed a task analysis. It was defined as an identification of skills from the manuals; manuals written by the manufacturer of a given product. I would like to suggest a different system for developing a task analysis and a new format. While the task analysis format and system that is presented here is probably not absolutely fool proof, it has done what it was designed to do for fifty occupations in Michigan, and I feel certain it will do the same for ABACUS. Again, I must stress

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the need for a very thorough task analysis. Without it the content of the instructional packages (modules) are at the mercy of a technical writer. The task analysis also lays the foundation for the identification of the components of the "needs assessment."

d. In order to do quality individualizing of instruction that addresses the specific job skills needed for a particular occupation, it is necessary to identify precisely what it is that a person does to function effectively and satisfactorily as defined by the fact he has retained the job and received satisfactory ratings. You have to go to the person doing the job in the field. You go to him with an instrument he can respond to. Let's take a close look at a task analysis system and format that does just that.

Task Analysis

a. Given the assumption that the occupation selected is one in which pretraining is needed and that jobs do exist and are projected to exist for a reasonable time, individuals who are functioning in the said occupation are brought in to draft the tasks that will be listed in a precise order on a prescribed format. These individuals are referred to as "Advisory Channels" and it is suggested that a minimum of five to seven are used. Depending upon the nature of the field, people representing different size units or different circumstances, but still carrying the same job classification, must be included. It has been found that inputs from this group are better and faster if they are never brought together as a committee but work independently funneling their data into a central leader. The leader's task is to sift the information into one document.

b. The Advisory Channels are asked to provide data in five categories. They are asked to do so in a preorganized manner. The first area is to list all Job Skills that a person does on their job. These are explained as the hands-on, observable functions that anyone could record as visable, if someone followed him around. These skills are grouped under headings (units of learning). This assists the advisor in concentrating on all skills (tasks) under that heading. This also helps the person who will respond to the document in ascertaining its completeness and continuity. The advisor starts all skill statements in the same way: The technician is able to ___________.

c. The second category speaks to the Knowledges needed to do the list of skills. Again, they are grouped under the same headings and must be tied to a skill or skills. This is done in order to keep the "excess baggage" out of the resulting curricula. Knowledges are defined as an understanding needed in order to problem solve. They are not just simple pieces of information, but rather information in order to "decide". The third category deals with Behaviors peculiar to the job. Items dealing with ability to take responsibility, make decisions, handling of authority, etc. fall under this category. The fourth category deals with Basic Skills. Basic Skills are defined as the reading and arithmetic skills necessary to function on the job. Finally, the last category deals with the Pieces of Equipment and Tools that must be mastered.

d. You will find attached a copy of the format for the first two categories. You will notice that Exhibit I, Job Skills, asks the interviewer to indicate entry and frequency of performance. Both are defined and parameters set. Of course these can be changed if needed. Perhaps another breakout might be needed indicating battle and nonbattle conditions that will effect both entry time and frequency of performance. Exhibit II deals with the accompanying job knowledges and sorts out the "nice to knows" from the "absolutes." Since the relation between skills and knowledges has been emphasized during the writing of the instrument, this will further help in developing a curriculum hierarchy. The tying of knowledges to skills will assist in insuring that instructional packages will present the theory and then reinforce it by having the student-trainee immediately apply it. We thus do away with theory modules and skill modules and end up with an integrated (skill-knowledge) module.

e. Taking just a moment to back up and deal with the term curriculum hierarchy, I think a further explanation is needed. This refers to the fact that the absolutes are required and the "nice to knows" can be taken if the student has time available to him.

f. Both categories number each task separately for use by the computer. Let's take a look at exactly what has to be done in order for the computer to analyze the resulting data. If you are dealing with several occupations within the same occupational family, you still use one instrument and one leader, but separate Advisory Channel groups. The leader sorts the common tasks being sure where they are identical they are worded accordingly. Once the instrument is finalized, only the occupation title changes. (See Exhibit I.) Directions are given to each person being interviewed to respond only to the items that pertain to him, the occupation at the top of the analysis form. However, if you are just going to offer one occupation within the family, an analysis need be done just on that one. The first case does allow you to establish a career ladder by defining the commonalities between the occupations. This enhances the learning environment as each student finds his own level. He goes as far as he can as fast as he can along that ladder, mastering each skill to the performance criteria indicated until he can do no more.

g. I have enclosed copies of computer printouts (Exhibits III, IV, V) for Job Skills, Commonalities, and the relationship of Job Skills to Job Knowledges.

h. Now let's take a look at the administering of the survey instrument. The size of your population should be determined and categorized. Once it is stratified then a percentage should be randomly selected from each category. Our population sample in Michigan had to be influenced by time and dollars. We did add a few rules that helped insure the validity of the data received and that was: (1) the person in said job classification must have held the job for a minimum of one year, but not more than five, and (2) they had to be holding the job at present, no supervisors or foremen could respond. The reasons, of course, in the first case is simply that one year allowed the entry items to be distinguished from the nonentry and the maximum of five years helped prevent a memory lag of what was and wasn't entry. The second case is supported by research in that supervisors, etc., and the worker, both filling out the same survey, find there is as much as a thirty-five percent discrepancy in the responses.

i. Once the instruments are filled out, the computer does the rest. It accepts a task that receives a given number of responses in entry and frequency, and sends into review those that do not. It spells out the commonalities. In other words, it gives you a very good base from which to develop curriculum systems and materials.

Instructional Packages (Modules)

a. If your first phase, task analyses, has been well done, the task statements are the performance you desire and thus the performance part of the performance objective. You have a very detailed job description or course outline if you prefer. Each statement can now be expanded into a module of instruction allowing for CMI and appropriate CAI.

In addressing the area of modules, it will be presented in the following categories:

(1) Format

(2) Comprehension

(3) Types

(4) Testing

Format

a. The adoption of one format assures uniformity and eases the student's movement both through a course and from course to course. There will be those individuals who will want to develop their own way or modify the accepted format, however, we have found that unless the modification is desirable for the instructional system as a whole, it should not be allowed. We have developed and are using one format that works equally well for all of our seventeen (17) courses and fifty-four (54) occupations. The Army may feel that this format will work, or a reordering up of the same information is necessary, whatever the point is to gain consistency.

b. There are five parts to a module whether it is used for CMI or CAI: (1) identification (cover) page, (2) the performance expected, (3) the information and understanding needed, (4) the actual steps in learning, and (5) the technical work vocabulary list. Let us discuss them in the order just listed. This is the sequence that through trial, error, and revision, has worked. A copy of each follows with appropriate explanations.

c. Page 23 is the identification page and thus serves as a cover sheet. If this module were on a slide (slide-tape presentation), it would serve the same purpose. The reader should realize that for ease of presentation, the written module is being used as an example, but the same would apply no matter what medium was selected. Most of it is self explanatory, but level and occupation should be expanded. Level refers to the type of module (skill, transfer, etc.) and occupation demands that all occupations that require the mastery of this module be listed. This gives the students a chance to see commonalities between occupations and courses.

d. We struggled with many performance objective formats and have found this to be the most readable and understandable for the greatest majority of the students. It still encompasses the essential ingredients of conditions, performance and criteria. (See page 24 .)

e. Many times there is information needed by the students before they can start the actual steps in learning a skill. This is where simple information is given, the reason it is necessary, and the introduction of knowledges needed to do or solve the succeeding steps. This is where the relationship of the Job Skills and Job Knowledges becomes evident and the instructor presents it here and in the ensuing steps.

f. The Job Step Section on page 26 is a very detailed, programmed step by step process of learning the identical task. It should be presented in a very relaxed speaking narrative tying the knowledges to each step as they apply, all the while reminding the student of pertinent past experiments and applicable learnings. It should be so clear it would be as if you were verbally explaining the task to a very slow learner.

g. Finally, new words, especially technical words, will be introduced to the student. (Page 28) The beginning modules will be heavy in this area with it falling off toward the end. This should be used as a minidictionary, keeping the definitions as simple as possible.

h. In writing modules you should start with the very simple, moving to the more complex, building upon previously gained skills and knowledges. By the same token, you must start with the concrete easily demonstrable skills, to the more abstract that might require a student to problem solve and troubleshoot.

Comprehension

Every module should have to go through and pass several tests. First, the reading level of all modules should be constant. A fourth or fifth grade reading level is suggested, and writers can be taught to do this with comparative ease. Second, an individual totally unfamiliar with the subject matter should silently read it for continuity and flow. They should then answer one question without referring back. What is it you should be able to do when you finish the mod? This, another individual should read it aloud to someone else. This will point out glaringly, run on sentences, grammatical errors, inconsistencies, and punctuation mistakes. Fourth, a brand new student whose reading level tests out at about fourth grade should do the module. An evaluator, not the module writer, should be with the student to check for stumbling blocks, assumption of knowledge, etc. While this sounds involved and somewhat time consuming, it does not take that much time and should improve the end product tremendously.

Types and Testing

a. While at Fort Gordon, we had an opportunity to get a look at some of the written materials being used by the students. It was apparent that a great percentage was at a high level of learning, in other words troubleshooting (application of theory). There was some written at a level just below troubleshooting, the synthesis or project level. It did not appear as if the curriculum had gone from the simple to the complex, and concrete to the abstract, but had instead jumped in somewhere in the middle. It is therefore recommended that there be at least four levels. Each level will build upon the other, reinforcing the learning through problem solving and practice.

b. The first level should be the single skill or operations module. Often mock-up trainer units, workbooks, simulators, etc. are used to teach the single skill. It is a straight forward step-by-step programmed learning process that is set forth in the most simplistic of manner.

c. The second level builds upon the first. This module is called a synthesis, integrated, or project module. The term is not particularly important, but the concept is vital. The skills are brought together into one module or a related series of modules dealing with one concept. This allows the student to see the relationship of the part to the whole.

d. The third level deals with troubleshooting or problem solving and thus is a level that might not be mastered by all students. A situation including its parameters is set before the student with only guidelines for his thought processes, not specific how to steps. The steps taken must be spelled out by the learner to be checked by the instructor. This encourages understanding as opposed to mechanically learning a task.

e. Level four is a transfer module. Since any training environment has its limitations, a student must be prepared to handle the unfamiliar. A student may learn to do a process a certain way or to handle a certain brand of equipment and run into a different piece of equipment or way of doing a task. He must be able to transfer his learning from a familiar to a similiar, but not identical situation.

f. The testing materials that were available for review appeared to deal with the cognitive areas. It is suggested that with the developing of modules as previously laid out, that the demonstration of the skill will indicate that theory has been mastered and thus applied. Cognitive testing under this system, would be just to to check point along the instructional path and not the end. As a matter of fact, Level III can act as a pretest for purposes of determining individual curriculum starting points. This will give you a good measure of both cognitive and psychomotor learning.

Needs Assessment

a. Perhaps one of the most frustrating things for a learner is to find he is ill-equipped to handle the material. A good Needs Assessment will allow each learner to start where he should, giving him credit for competencies previously learned and prescribing training in areas where he needs it. There are three levels of Needs Assessment depending upon how academically handicapped your students/trainees may be.

b. The first should be given to all, and it deals with the equated arithmetic, reading, and behaviorial skills needed in order to be tained in the identified occupation. This will allow the instructional system to provide pretraining basic skills. Most students have virtually no problems handling this as they are being asked to do only what is necessary to succeed. The logic is obvious as you can show them where they are at present and where they need to go. In a few students the deficiency will be so insignificant that often the basic skill and occupational training can be done concurrently.

c. The second level of Needs Assessment should be done where there is a doubt as to the individuals ability to handle the material, even if the above basic skill training is provided. This is usually done with the academically damaged student. In every skill to be learned, there is an assumption of past learning that goes beyond the reading and arithmetic. These are the things we would take very much for granted. Case in point, the trainee is being taught to take a pulse. The assumption might be that the student knows what a pulse is and what it represents. Another might be to check a starter on a car. One of the assumptions might be that he even knows how to start a car or where the starter is located.

d. Any training situation includes assumptions of prior learning, a few can be taken care of by including them in the modules, other should be pretested.

e. The third and least used level will be reserved for special cases. Every occupation has physical activities and conditions that may preclude some people from being trained. These will measure a person's dexterity, coordination, ability to discriminate, ability to remember, and follow instructions both written and verbal. The assessment will deal, to use an example, with Bi-Manual Coordination, Eye-Hand-Foot Coordination, Eye-Hand Coordination, Work Rhythm, and so on. Further, if you needed to know whether a person could be trained for let's say a job of Rubber Stamper. You would check him on the following activities by means of a prescribed work sample: Neatness, following verbal directions, following a model, counting ability, eye-hand coordination, and work rhythm. If you were considering training him as a Sign Maker, you would check spatial discrimination, form discrimination, planning ability, neatness, organizational ability, eye-hand coordination, and measuring ability.

Summary

The three areas discussed are components essential in the establishment of an individualized instructional system. A firm base is necessary, and the writer feels strongly that CMI should be developed prior to CAI. Then, CAI can take its rightful place, as but another instructional tool.

capital area career center

MODULE ____________

PROGRAM: ____________

INSTRUCTIONAL UNIT: ____________

____________ # ______

MODULE TITLE: ____________

____

____________ # ______

DATE: ____________

LEVEL: ____________

OCCUPATION: ____________

____

____

____

____

____

____

Industry has told us that they require you to know and be able to do the following skills. Take your time. Read very carefully. Ask questions.

Read the objective as if it were one sentence--your instructor will show you how.

PERFORMANCE OBJECTIVE

YOU ARE GOING TO LEARN:

AND IN ORDER TO DO THIS YOU WILL BE GIVEN:

WE WILL KNOW YOU CAN DO IT (PASS) WHEN:

TEST
AND
EVALUATION

TURN TO NEXT PAGE

INFORMATION YOU NEED

DIRECTIONS:

In order to be able to understand and do the job steps, do everything on this page before going to the next page. Ask your instructor to help if you need it.

INFORMATION	MATERIALS (List chapter, page, etc.)	WHERE YOU WILL FIND MATERIAL
You need this information because:		

Turn to Next Page

JOB STEPS

DIRECTIONS: Do in the exact order listed.	Equipment & Materials Needed (See Page 2)
Step 1. For the materials and equipment you will need to complete the following steps, reread the Goal (page two). Any additional material needed to learn the skills will be listed in the Equipment & Materials column on this page.	
	Turn to Next Page

JOB STEPS

DIRECTIONS: Do in the exact order listed.	Equipment & Materials Needed (See Page 2)
Now have your instructor check your work. (See page 2 for Test & Evaluation.)	

MODULE ____________________

TECHNICAL WORDS

Found In Job Step Number	Words	Meaning

Exhibit I. CRITICAL INCIDENT ANALYSIS

Occupation:

Job Skills	*Entry Skill	Estimate of Performance Frequency (during a 6 month period) 0% (Never)	10-15% (Seldom)	16-25% (Sometimes)	26-35% (Frequently)	36 % (Often)	Office Use Only
	YES NO						

*It was required of you within the first 60 days of the job.

Exhibit II. CRITICAL INCIDENT ANALYSIS

Occupation: ____________

Check what a beginning (entry) ____________ does and does not need to know to do the job he has to do.

Job Knowledges	Absolutely Necessary (to do skills you just checked)	Completely Unnecessary	Nice to Know	Office Use Only

Exhibit III. Job Skills

Accept or Review by Category

*** Cluster- Business and Visual Communication Occupations
** Program- Data Processing Occupations
* Occupation- Keypunch Operator

Code No.	Job Skills Description	No. Surveys	Entry Skill	% of No. Response	0-10%	11-25%	26-50%	51-75%	76%+		Accept Review
	A Program Card utilizing the following fields: Numeric	15	Yes--86%/13	06%/01	60%/09	00%/00	13%/02	00%/00	00%/00		Accept
	Weight Factor				6.0	0.0	3.9	0.0	0.0	Tot Weight	9.9
13008	To make, load, and properly use a Program Card utilizing the following fields: Alphabetical.	15	Yes--86%/13	06%/01	60%/09	00%/00	13%/02	00%/00	00%/00		Accept
	Weight Factor				6.0	0.0	3.9	0.0	0.0	Tot Weight	9.9
13009	To make, load, and properly use a Program Card utilizing the following fields: Automatic D up.	15	Yes--86%/13	06%/01	60%/09	00%/00	13%/02	00%/00	00%/00		Accept
	Weight Factor				6.0	0.0	3.9	0.0	0.0	Tot Weight	9.9
13010	To make, load, and properly use a Program Card utilizing the following fields: Automatic SKIP.	15	Yes--86%/13	06%/01	60%/09	00%/00	13%/02	00%/00	00%/00		Accept
	Weight Factor				6.0	0.0	3.9	0.0	0.0	Tot Weight	9.9

Accept or Review by Category

*** Cluster- Business and Visual Communication Occupations
** Program- Data Processing Occupations
* Occupation- Keypunch Operator

Code No.	Job Skills Description	No Surveys	Entry Skill	% of No Response	0-10%	11-25%	26-50%	51-75%	76%+		Accept Review
13011	To make. load, and properly use a Program Card utilizing the following fields: Automatic LEFT Zero Fill.	15	Yes--33%/05	53/%08	33%/05	00%/00	06%/01	00%/00	00%/00		Review
	Weight Factor				3.3	0.0	1.8	0.0	0.0	Tot Weight	5.1
13012	To operate the verifier: To OP										

Characteristics - To be able to perform routine maintenance on machines.

*Required in Programs

OCC		Title-Name
13000		Data Processing Occupations
	132	13059 Unit Record Operator
	133	13059 Computer Operator

Characteristics - To block sort and select certain fields from the card.

*Required in Programs

OCC		Title-Name
13000		Data Processing Occupations
	133	13023 Computer Operator
	132	13023 Unit Record Operator

Characteristics - To clear card jams from all of the machines.

*Required in Programs

OCC		Title-Name
13000		Data Processing Occupations
	133	13058 Computer Operator
	132	13058 Unit Record Operator

Characteristics - To clear the machine of card jams if it occurs.

*Required in Programs

OCC		Title-Name
13000		Data Processing Occupations
	133	13044 Computer Operator
	132	13044 Unit Record Operator

Exhibit IV. Commonalities Characteristic Report (Cont)

Characteristics - To code for Programming: Prepare mathematical statement of common business problems to facilitate programming procedure.

*Required in programs

	OCC	Title-Name
13000		Data Processing Occupations
	133	13072 Computer Operator
	134	13072 Programmer

Exhibit V. Job Knowledges Related to Job Skills

13000 Data Processing Occupations

Job Knowledge	Job Skill
13501	13001
	13002
	13003
	13004
	13005
	13006
	13007
	13008
	13009
	13010
	13011
	13012
	13013
	13014
	13015
	13016
	13017
	13018
	13019
	13020
	13021
	13022
	13023
	13024
	13025
	13026
	13027
	13028
	13029
	13030
	13031
	13032
	13033
	13034
	13035
	13036
	13037
	13038
	13039
	13040
	13041
	13042
	13043
	13044
	13045
	13046
	13047
	13048
	13049

Characteristics - To be able to perform routine maintenance on machines.

*Required in Programs

OCC	Title-Name
13000	Data Processing Occupations
132	13059 Unit Record Operator
133	13059 Computer Operator

Characteristics - To block,sort and select certain fields from the card.

*Required in Programs

OCC	Title-Name
13000	Data Processing Occupations
133	13023 Computer Operator
132	13023 Unit Record Operator

Characteristics - To clear card jams from all of the machines.

*Required in Programs

OCC	Title-Name
13000	Data Processing Occupations
133	13058 Computer Operator
132	13058 Unit Record Operator

Characteristics - To clear the machine of card jams if it occurs.

*Required in Programs

OCC	Title-Name
13000	Data Processing Occupations
133	13044 Computer Operator
132	13044 Unit Record Operator

Characteristics - To code for programming: prepare mathematical statement of common business problems to facilitate programming procedure.

*Required in Programs

OCC	
13000	Data Processing Occupations
133	13072 Computer Operator
134	13072 Programmer

Biographical Sketch

William F. Fitzgerald, Ph. D.

Dr. Fitzgerald holds Bachelor's and Master's degrees in Psychology (the latter with an emphasis in clinical and psychometrics) from San Jose State College, and the degree of Doctor of Philosophy in Education from the University of Chicago. He has been involved with computer assisted instruction since 1965 and has done extensive consulting in the areas of computers and training technology.

In 1971, he joined the faculty of the School of Dentistry at the University of Michigan, and assisted in the development of a five-year $4.3 million effort to design, produce, and deliver individualized instructional materials (in all media including computer assisted instruction) for dental education. Dr. Fitzgerald served as the Director of the CAI-DENT Center until January, 1975 when he became the Director of the Division of Educational Resources and Studies of the American Association of Dental Schools.

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COST/BENEFIT ANALYSIS

Project ABACUS

Submitted in partial fulfillment of Task Order 75-129 by:

William F. Fitzgerald, Ph. D.
Director, Division of Educational
Resources and Studies
American Association of Dental Schools
February 1975

Section 1. Cost/Benefit Analysis

a. General Purposes

Cost analysis is a complex, multi-faceted process with diverse purposes. At a minimum, it is a procedure of categorizing and quantifying an activity in the common metric of money. For the purposes of the ABACUS Project, the following objectives of cost analysis will be identified, and some of them will be discussed in detail.

(1) Activity Separation. In a complex environment it is a desirable objective to determine the costs associated with each sub-activity. The presumption of this purpose is that if priorities or resources change, this analysis will provide administrators with the data that are needed to respond to change.

(2) Staff Efficiency. In computer assisted instruction, there are numerous tasks to be accomplished. Tersely stated, entry level behaviors (achievement) and learner characteristics (aptitude) must be specified; content must be identified and organized; and instructional program (assuming that systems software and an applications language exist) must be written and coded; code must be entered into a computer in machine-readable form; material must be evaluated on a representative sample of the target population; and revisions in content and logic must be made to reflect the results of the field test. For a single person to perform all of these tasks, training/education in the skills not possessed must be accomplished, and one individual will be (presumably) paid to perform tasks that could be accomplished (in many cases probably better and faster) by someone at a lesser salary. Conversely, the epitome of a specialist team approach would require an educational psychologist, a content resource person, an instructional programmer (both educational logic and applications software), a key-entry operator, and delivery/evaluation personnel. Such a mix of persons creates potential cost through A: a) idle time due to imprecision in coordination or b) administrative expense to coordinate

the team, and B: need for interaction between pairwise linkage of personnel through the sequence of software generation. Cost analysis can yield generalizable results to indicate the efficient utilization of staff.

(3) Job Estimation. With widely varying degrees of precision, activities can be analyzed to predict future costs. The similarity of future activities to those currently or formerly in operation plays a major role in the precision of estimate, of course, but a priori cost analysis (in this case an analysis of expected costs) based on quantified parameters can and does form the basis for decisionmaking.

(4) Personnel Control. Whether the subject is number of diodes quality control tested per week, or number of instructional programs generated per year, an important component of and use for cost analysis is the assessment of personnel performance. The latter case is decidedly more complex, but there are at least bandwidth guidelines which can be determined from past performance and used for comparison in the future.

(5) Method Comparison. The literature of CAI is rife with appeals for or attempts at comparison of CAI with Traditional Instruction (TI). Most efforts to date are replete with serious methodological and philosophical problems, and because of the importance of this area to ABACUS, this topic will be addressed in detail in a subsequent section of this report.

(6) Scarce Resource Allocation. In the most general sense, resources and costs are mutual inverses, and include space, time, personnel, and supplies among other items. When any resource is in short supply (and ignoring for the moment the question of whether it is available at any "price"), cost analytic procedures can indicate the effect of allocating varying mixes of that resource among potential recipient projects. It must be emphasized that this purpose of cost analysis is an extreme sub-set of all cost analyses, since it is an underlying assumption that cost is to be minimized (resources are to be allocated to maximize profit).

b. The Metric of Method Comparison

One of the most frequent uses of and requests for cost analysis is generally termed cost/benefit analysis. At the risk of selfish indulgence, the author is not resisting the temptation to lapse into psychologese to speculate that administrators have been searching for assistance in decisionmaking and hope they have found it in the (occasionally spurious) quantification of alleged benefits. Assuming that all costs (including space, faculty time, student time, equipment, supplies, etc.) have been specified and quantified, what then is the metric of benefit?

(1) Benefits Necessarily Multiple.

(a) Edmund W. Fitzpatrick, President of the Educational Technology Center, proposed recently (1973) that cost-effectiveness be expressed in dollar amount spent to achieve a unit of learning gain. The latter was defined as mean posttest less mean pretest. Such an analysis assumes equal intervals among units and a defensibly definable zero point in the domain of the unit metric, which topic is potentially the subject of its own monograph, however. Fitzpatrick suggests that it is necessary to assess a) the cost per unit of learning gain, b) from among those alternatives that meet minimum acceptable performance levels, in addition to c) the acceptability of a program (by both faculty and students), and d) how well it is meeting its other objectives (he cites amount of student time as an example). The point to be drawn here is that Fitzpatrick is avoiding the issue by proposing an apparently objective quantification scheme, while then augmenting his formula (dollar per unit of posttest less pretest) with border conditions ("acceptable" alternatives, program "acceptability", and "other" objectives) that are presented as binary. He fails to account for the variations among degrees of acceptability, etc. It is at least obvious from these points that the benefit side of a cost-benefit equation is complex and not uni-dimensional.

(b) Within the domain of benefits are the immediate administrative concerns of a) the same results for less cost, b) better results from the same cost, and c) the timing of capital outlay relative to the accrual of results. To these must be added the "softer" benefits of a) student satisfaction, b) greater assurance of mastery of each student, and c) increased flexibility in the receipt of the "raw materials" (untrained students) and delivery of the "finished product" (graduates). Note that cost was defined earlier as money, time, space, etc. Hence, early delivery of graduates (Δ t) is part of "the same results for less cost," and better-trained graduates (Δ p) is included within "better results for the same cost."

(c) The softer benefits are more crudely measured. Student satisfaction, for example, can be intrinsically measured by psychometric devices ranging from evaluation or appraisal checklists to personality inventories, and its rather gross extrinsic measures include attrition from the training program, poor on-the-job performance, and request for job assignment different from that for which the graduate was trained. In a very real sense, these extrinsic measures comprise the "bottom line" of the training program, but within locally defined reason, attention devoted to the intra-program satisfaction measures may well affect the extrinsic characteristics.

(2) Quantitative Parametric Comparison

(a) Table 1 illustrates quantitative aspects of cost/benefit functions. The references to traditional and technological instruction are included to imply two methods of which the first is necessarily linear in cost (no start-up costs, fixed enrollment, and static student-faculty ratio), and of which the second is non-linear.

Table 1. ILLUSTRATIVE QUANTITATIVE PARAMETERS

Course Name: Basic Electronics

Traditional Instruction:

A. Clock Hours: 210

B. Delivery Expense (per student): $875

C. B divided by A: $4.16

Technological Instruction:

D. Clock Hours (average): 165

E. Start-up Costs: $212,000

F. Delivery Expense (per student): $515

Assuming 1000 students/year for 5 years:

G. Traditional Instruction 5 year cost: $4,375,000
(1000 students/year x 5 years x $875/student)

H. Technological Instruction 5 year cost: $2,787,000
((1000 students/year x 5 years x $515/student) + ($212.000))

I. Technological Instruction Cost per clock hour based on 5 years, 1000 students/year: $3.38
(($2,787,000 divided by (1000 students x 5 years x 165 clock hours/student (average))

J. Cost percentage (H divided by G): 63.7%

K. Time percentage (D divided by A): 78.5%

L. Efficiency Ratio (H divided by (1000 students/year x 5 years x 210 traditional hours)) : 2.65

M. Traditional Instruction (weeks to completion): 5.25 (fixed)

N. Technological Instruction (weeks to completion): 3.3 (average)

O. Completion percentage (N divided by M): 62.8%

(b) Early in the application of cost/benefit techniques to instructional environments, the metric of benefit was the student-contact hour (SCH). This derived from what Dr. Warren Seibert of Purdue University labeled the "sunburn" theory: expose a student to the golden (rays of sunshine) words of wisdom for X hours, and his (skin) learning behavior will change. The analogy of the SCH in technological instruction must be expressed as an average since the process of promoting a learner among stages in the program heirarchy at his own pace necessitates completion at different times for different students. The non-linear cost aspect of technological instruction is reflected in the reference to start-up costs.

(c) This distinction parallels the academic study of the business world in which a distinction is made between labor-intensive and capital-intensive ventures. The former describes a group of 87 accountants working with pencil and paper, and the latter implies replacement with a computer (large one-time capital outlay) and seven accountants. The first has essentially no start-up cost but incurs a large cost per unit; the second requires a large start-up cost but yields a smaller cost per unit.

(d) Any comparison between the two methods requires a specification of time duration. Based on the data in Table 1, for example, if only 500 students in total were involved, traditional instruction would be preferable, ignoring other cost/benefit aspects. 500 x $875 = $437,500; (500 x $515) + $212,000 = $469,500. Arbitrarily, the analysis in Table 1 illustrates 1000 students and five years. Elements A through F represent the source data for comparative analysis, and elements G through O illustrate the results of manipulations of the source data under the assumptions of student rate per year and duration. Note that for the sake of simplicity, delivery expense is listed as a single dollar cost to aggregate space, faculty cost, materials, etc.

(e) The analogy of SCH for technological instruction can be calculated only in the presence of the assumptions (student rate and duration). Herein lie the faults of the cost per SCH metric as an index for assessing technological instruction: a) five-year cost H is lower, b) clock hours are fewer, and c) there is no stable rationale for comparing cost/SCH between the two methodologies ($4.16 and $3.38 in this illustration). More meaningful data, despite the fact that they are gross and macroscopic and confound numerous variables, are the cost and time percentages. But even these are not wholly representative of the advantage of investing resources (again, time, space, personnel, etc.) in technological instruction.

(3) <u>The Efficiency Ratio</u>. There is an implied commitment in the curriculum design (or, more properly, curriculum practice) that a course of 210 clock hours <u>does</u> produce performance. Hence, the sensitive metric of comparison of a traditional method with a technological one needs to reflect the cost (of the technological method) to produce mastery (as expressed in time required by the traditional method).

The elegance of this measure is that it exemplifies the pursuit of cost/benefit analysis in the ultimate sense: What does it <u>cost</u> to achieve a known benefit? Note especially that thus far, this rather simple technique is presented in the context of method comparison when both are known and, presumably in operation. The next section (c, below) will propose a projection of the technique into environments which are not yet taught technologically.

(4) <u>Another Quantitative Measure</u>.

(a) The student contact hour has received much attention in public or elective education environments because the mandate of learning per unit of time is extremely less emphasized than in military-industrial applications. In the latter case, time is truly of the essence to some degree. Consequently, it is incomplete to base resource commitments solely upon a measure of clock hours to mastery; the distribution of those hours within the day and week are also of substantial importance.

(b) Among the reasons to justify technological instruction is the rather glib statement that mediated (instructor-absent) learning environments allow the student to proceed at his own pace. The less-often identified administrative implication of that statement is that when information is presented by a machine, the instructor (who may be eating, sleeping, or enjoying a well-earned moment of leisure) does not need to be present. Thus, instead of testing the endurance of an instructor beyond 8 hours per day (divided into 210 (A) equals 26.25 days, which, divided by 5 (days per week) equals 5.25 weeks to completion (M)), it is possible to motivate the student to access mediated instructional materials 50 hours per week (divided into 165 (D) equals 3.3 weeks to completion (N)) at times he elects. Thus, another quantitative measure of the benefit of technological instruction is weeks to completion and, comparatively, the completion percentage (O). The supply of raw materials (students) in a timely manner and the shipment of the finished product (graduates) are subjects worthy of receiving attention elsewhere (but are not addressed in this report).

c. <u>Estimating Future Applications</u>

The techniques discussed in the prior section address comparisons between existing, presumably parallel methodologies. How can the cost/benefit parameters of technological instruction be estimated in the absence of a full commitment to establish it?

(1) <u>The Traditional Method Exists</u>. Within rather loosely-defined guidelines, it is possible to analyze the content and objectives of instruction, and to compare the abstract features of an existing traditional method with those similar features which characterize a technological effort. By implication of similarity, generalizations can be made based on the extent and nature of the effort devoted to the

former technological development, and these approximations will provide an initial estimate of the probable costs and benefits of translating the traditional instruction into a technological format. Table 2 illustrates one possible taxonomy of abstract instructional characteristics. Because the nature of such an analysis is highly content-specific, no further elaboration will be made. Fairly precise estimation can be performed independent of the potential benefit of this comparison of abstract characteristics, however; a proposed technique for this estimation is the subject of the next section I, c, (2).

(2) The Traditional Method Does Not Exist. Aye, here's the rub. When approaching an instructional task de novo, there exists the choice of implementation in a traditional or a technological format. Since the early development stages (identifying entry-level behavior, determining learner aptitude, content sequence, structure, and task analysis) should be identical whether either teaching method is known (or specified) a priori, the basic lesson plan will be established. If the leverage (student rate and duration) is great, simulations of each method are well worth the time and expense. What is being proposed here is the development of a simulation of each method, using a small number of students.

(a) Simulate the Traditional Method.

1 Microteaching was proposed by Dr. Kevin Ryan of the University of Chicago (the initial literature was published while he was at Stanford University), and has received wide acclaim primarily as a technique for training primary and secondary level teachers. An unexpected spin-off, however, was the realization that the learning performance of the students was a confounded (in the sense of unseparated variables) effect of both the instructor and the lesson plan. Hence, with a proven lesson plan, a novice instructor can be evaluated, and with an experienced instructor, an experimental lesson plan can be evaluated.

2 The basic technique of microteaching involves a physical setting essentially identical to the real-life classroom environment, and with a class size of six to eight students that represent a stratified sample of the student population. In the teacher training application, "classes" are split-screen videotaped with one camera on the class and another on the student teacher. The tapes document the class sessions for critique by an education faculty member in the presence of the student. For the purpose of the simulation proposed here, an upper bound of student time to reach mastery can be established with trial handout materials and orientation of the instructor to "pretend" that he is teaching to a larger class size. This exercise will yield not only an upper bound of time (upper bound because of the presumption that materials, sequence, etc., will be refined for successive presentations of the course), but valuable data for course revision whether finally delivered (to students) traditionally or technologically. Analysis of this simulation will yield estimates similar to A through C in Table 1 for use in

calculating comparative parameters (G through O in Table 1). How, then, can comparable estimates be obtained for technological instruction?

(b) Simulate the Technological Method

1 This author has been asked to exemplify computer assisted instruction in the absence of a computer. In many a hotel corridor and airport limousine, the game has been played as follows:

Skeptic: Don't put me on!

Fitzgerald: O. K., I'll play the part of the computer and you answer any way you want; do you know what the successor of a number is?

Skeptic: Sure, it's the next number higher.

Fitzgerald: Please answer "yes" or "no".

Skeptic: Yes

Fitzgerald: Good, but I am going to ask you to prove it; what is the successor of 3?

Skeptic: 4

Fitzgerald: Good. Now tell me, what is 8 times its own successor?

Skeptic: Huh? You mean 8 times 9?

Fitzgerald: I'm sorry, I did not understand your answer. I am programmed to expect a numerical response to this question; please try again.

etc.

2 Despite the raised eyebrows one receives from strangers who walk into the middle of this simulation, it does make its point. What is being proposed is an unpolished sequence of technological modules that present an upper bound (in time) estimate of the learning of a representative sample of students (in the best design pairwise matched with the characteristics of the student sample proposed in I.c, (b), 1 above.) Quick videotapes can now be made with a Sony Porta-pak; trained personnel can simulate an instructional computer program (note: tape record the conversation for unanticipated response data to be used in the CAI programming effort); and first-approximations of slide/tape programs can be quickly prepared in storyboard format with a Polaroid camera.

Table 2. DETERMINANTS OF THE CHOICE OF LEARNING ENVIRONMENTS

1. Nature of the content: verbal, still visual, moving visual, auditory, positional, etc.

2. Nature of the response: written, spoken, behavioral, etc.

3. Time available: a) for the acquisition of the behavioral; i. e., perishability of the stimuli, b) for the demonstration of the response.

4. Problems to solutions:

   A. content: verbal
   response: written or spoken--direct repetition from memory
   duration of stimulus: variable
   time allowed for response: variable

   SOLUTION: Printed text

   B. content: verbal and positional (partial cues)
   response: written, spoken, positional--demonstration by analogy
   duration of stimulus: variable within constraints
   time allowed for response: variable within constraints

   SOLUTION: Lecture

   C. content: verbal and still visual
   response: written, spoken, positional--demonstration by repetition or analogy
   duration of stimulus: variable
   time allowed for response: variable within constraints

   SOLUTION: Slide/tape (text, still pictures)

   D. content: verbal and moving visual
   response: written, spoken, positional--demonstration by repetition or analogy
   duration of stimulus: fixed but replicable
   time allowed for response: variable within constraints

   SOLUTION: Videotape (movies)

   E. content: verbal, auditory, positional
   response: verbal, positional--demonstration by repetition or analogy
   duration of stimulus: fixed but not critical
   time allowed for response: fixed but not critical

   SOLUTION: Psychodrama

Table 2. DETERMINANTS OF THE CHOICE OF LEARNING ENVIRONMENTS (Cont)

F. content: auditory, positional
response: verbal, positional--demonstration by repetition or analogy
duration of stimulus: fixed and critical
time allowed for response: fixed and critical

SOLUTION: "Live" interaction--ultimate experience

(3) Penny Foolish and Pound Wise.

A program of method simulation may draw skeptical and critical remarks from colleagues and financial officers, but if the leverage of the effort is substantial, the potential cost saving may grossly outweigh the simulation expense. The conduct of such a parallel program may receive well-founded criticism that each simulation is at best only a crude approximation of the potential end product, but the basic assumption here is that the methods are proportionately upper bounds, and that it is the time and expense ratio that is of interest.

Section II. Miscellaneous Comments

a. Instructional Programmer Training.

During the December 1974 site visit, the point was made that the structure of the instructional applications software was sufficient to "orient" untrained CAI program authors to the methodology of instructional program logic. Speaking ex cathedra, this author submits that many paradigms of instructional logic have been developed through experience, and an illustration of prototype examples may inspire novice authors to invent variations, and at least may save author program generation time by avoiding a re-invention of the proverbial wheel.

b. The Uses of Affective Data.

The relationship between personality attributes and type of learning environment is under investigation in a wide variety of diverse environments, but exploratory findings indicate that some relationships may exist. Since the ABACUS Project may be less subject to invasion of privacy (OMB) restrictions than other environments, it may be highly profitable to experimentally collect personality data.

(1) Student Selection/Rejection. Students selected at random to participate in instructional experiments have reported affective reactions to different environments. Some students have reported concern over personal initiative, study habit compulsiveness, and self-scheduling laxity. Some of these variables may predict success and failure in self-paced environments and profiles of affective traits could predict failure (resulting in cost waste).

(2) Program Modification. This author defines the goal of instructional systems technology as the optimization of:

(a) the greatest learning,

(b) in the shortest time,

(c) with the greatest long-term retention, and

(d) with negative affective reactions within threshold boundaries

It would be conceivable, although highly undesirable, to subject learners to an instructional situation in which the reward for performance was modest, but the punishment for failure was cruel. The first three parameters of the optimization function above could be fulfilled, but at the expense of anxiety, resentment, and hostility. The moral issue may be obvious and a question of degree, but as a practical matter, unresolved negative affect is frequently displaced symbolically both consciously and unconsciously. Since the expression of displaced agression is often insidious and well disguised, even from the subject himself, it may well behoove the Project to assess the affective consequences of technological training during a course.

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NOTE: For a well-presented illustration of a post hoc accounting method, do not be distracted by the content application, and examine a copy of:

Cost Analysis and Rate Setting
Manual for Animal Resource Facilities

available from:

Animal Resources Branch
Division of Research Resources
National Institutes of Health
Bethesda, Maryland 20014

Telephone: (301) 496-5507

Richard C. Horne, III (USA Ret.)

Richard C. Horne, III, Brigadier General USA (Ret.) was born in Savannah, GA, on 21 July 1920. He attended public schools in S. C., D. C. and VA. He graduated from Virginia Military Institute in May 1942 with a B. S. in Electrical Engineering. He entered the Army in May 1942. He served in the Pacific Theater from Dec. 1943 until Dec. 1945, culminating as company commander of the 38th Inf. Div. Sig. Co. He served in various staff and command duties until 1949. Then he was assigned for four years to Sandia Base, N. M. on special weapons.

Following a tour in Korea with the Signal Section of Eighth Army, he served for almost two years in Joint Military Headquarters in Japan. BG Horne returned from Japan and attended the Command and General Staff College at Fort Leavenworth for a year. Next, he served for three years at the North American Air Defense Command in Colorado Springs. Next, he had a one year tour at the Naval War College in Newport, Rhode Island.

In the summer of 1961, BG Horne commenced a two and one-half year tour of Izmir, Turkey, as the officer-in-charge of a 700-man multinational (7 services, 3 nations) communications facility utilizing large fixed-station equipment as well as hundreds of mobile equipments.

From Turkey, he was assigned as Signal Officer, III Corps, participating in the huge Desert Strike maneuver managing tactical communications for an independent armored corps in a maneuver covering thousands of square miles of desert and mountain.

The III Corps provided the first Corps type headquarters for Vietnam in 1965. He served as Signal Officer in the central region of South Vietnam managing tactical communications over an area as large as South Carolina under stress conditions during the early battles and build-up.

Following Vietnam, he served two years as the Director of the Communications Electronics Department of the Infantry School engaged in teaching of tactical communications to thousands of Infantry Officers and soldiers.

Commencing in 1968, he served as Commandant of the Signal School at Fort Monmouth. This school reached strengths (military and civilian) of over 13,000. After more than thirty years of service, he retired as Brigadier General in December 1972.

From 1 April 1973 until 1 April 1974, BG Horne worked as Sr. Research Engineer at Stanford Research Institute. He was involved with studies and proposals for research in tactical and strategic military communications, national and local disaster communications, public safety communications, and the use of computers in technical training.

CTS in the Production and Utilization of Technical Specialized Skills

by

Richard C. Horne III
Brigadier General USA (Ret.)

General

a. The United States Army has a growing need for increasingly numerous categories of technical specialized skills. This, paradoxically, has small relationship to the size of the Army, but is rather a reflection of the complexity of modern life and its technology. If we are to have modern weapons systems, we must have the technicians to operate and maintain them. Their categories (Military Occupational Specialities, or MOS) increase directly as the complexity of the machines increases. This problem is not completely, nor even significantly, of the Army's own making, so "simplifying the Army" or "let's get back to basics" is not the answer.

b. The answer is clear, but not simple, not easy, and not cheap. It is--quickly recognized valid requirements for skilled technicians --produce them to adequate standards as expeditiously as possible, and utilize them effectively.

c. The Army has recognized this requirement and is examining methods to fulfill it. CTS is one method, and seemingly one with the potential to fulfill it well, if exploited to the full. It is necessary, therefore, to examine CTS as a part of a system which produces and utilizes technical specialized skills--and not look on it as merely a novel and exciting way to use computers to teach.

The Production Phase

a. Production of technical specialists consists of recruiting, selecting, and training of individuals. These steps are further complicated by a limited supply of raw material, politics, confusion, lack of money, etc. These are formidable hindrances but apply to virtually any large complex endeavor in a modern country. Obviously, then, the production system must operate in spite of these hindrances, with minimum sensitivity to them.

b. Recruiting.

(1) Although the Army's technical specialists are certainly in the minority, the "glamour" of these specialities is widely used to attract enlistment. We are a nation of people living in close affinity with our technology, and our youth, regardless of technical aptitude, are inclined to respect technical things and skills as producers of status, a quality few prospective recruits have.

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(2) The recruiter, utilizing the salesman's tools of brochures, visual aids, and just plain salesmanship, endeavors to interest the prospect in particular MOS's the Army needs. If he is successful, the prospect is given an aptitude test battery, physical examination, enlists, and signs a contract for training in the skill he wants and the Army needs.

(3) The test battery is a gross sorter of aptitudes and basic intelligence. It is not a precise predicter of success in a particular technical skill. Likewise, the physical examination. For example, a color-blind man cannot enlist for most electronic maintenance skills due to his inability to perceive color coding of certain basic electronic components. The important thing to remember about the recruitment phase in this instance is that by gross sorting the Army bets that this recruit can be made into a certain type of technician. If it fails, or he fails, the Army must train him in some other MOS of the Army's choosing. If the Army makes an error and overlooks certain disqualifying scores on the test battery or a physical defect, and the recruit fails in his skill training for reasons associated with this overlook, then the recruit may, at his option, seek discharge or other training. There is a need, then, for as accurate aptitude determination as possible before the Army contracts to give skill training, often at a cost of many thousands of dollars, to a recruit. It seems reasonable that CTS, in its CMI portion, could produce feedback valuable to the test battery, allowing a more refined use of it. Perhaps better yet, CTS feedback data may facilitate the design of an aptitude test designed for the MOS desired by the recruit, to be given later in the recruiting process.

c. Basic and Skill Prerequisite Training.

(1) Basic training teaches the basic soldiering skills to all enlistees. It has no direct connection with CTS except to act as a further screening process. At one site of basic training, certain graduated basic trainees get training in basic electronics (COBET) before being sent to service schools for skill training in MOS's requiring electronics as a prerequisite. The amount of electronics training varies with the knowledge of electronics required in the forthcoming technical skill to be taught at a service school.

(2) This concept is a money-saver. No travel is involved. Experience has shown that, in the electronic skills, most of the attrition takes place in the early phases of the course, which is the basic electronics portion. It is expensive to transport a soldier a thousand miles to a service school, only to have him fail in the first few weeks and have to be transported to another service school or training center for alternate training. CTS must act as a feedback to this skill prerequisite training, refining the requirements for entry into the CTS course, and hopefully, lowering attrition.

(3) There seems to be no reason why other skill prerequisites common courses cannot be developed to take place at the basic training site. A course in basic mechanical skills, for example, for those entering mechanical MOS training. It seems entirely clear, however, that the skill courses of CTS must feed back to the skill prerequisite courses, and close coordination maintained among those who write these courses.

d. Technical Skill Training at Service Schools.

(1) The Service schools receive their trainees from the basic training site, gross-sorted by the initial aptitude test battery, the physical examination, and basic training. For those who have had skill prerequisite training, a screening has taken place. This screening gives the service school (CTS in this case) a probability of completing the training consistent with the validity of its process of date exchange and evaluation with previous test and training points. The point is, CTS can participate in selecting who enters its courses.

(2) The conduct of CTS training will not be dealt with here except to say that its continuous evaluation and prediction functions are vital in the individual's on-going training and the Army's management of its resources and requirements in the skill produced by the CTS course.

e. On-the-Job Training (OJT) and Initial MOS Validation.

(1) CTS has at this stage produced an apprentice technician in a time consistent with his individual ability, and has to some degree evaluated his potential. The Army, based on the earliest valid prediction of his graduation date, has arranged to send him to a unit where utilization of his skill commences. Although he is in a unit, and may be participating in unit training, an important part of his individual training remains. This is OJT, designed to raise him to the journeyman level, working in the environment particular to unit utilization of his skill.

(2) The service school (CTS) must provide the technical design of his OJT. CTS offers the potential of an OJT training package designed to the actual requirements of the individual, rather than one applicable to the "average" graduate of the skill course. CTS should be able to vary the suggested OJT package for a particular individual based on the evaluation of his service school performance, together with feedback data from the unit on former graduates of the school. The unit administers OJT to the individual and on completion, subject to the judgment of the unit commander, makes the initial validation of his MOS as a journeyman. Data on the individual's performance during OJT must be fed back to CTS in order to improve its teaching, evaluation, and prediction functions.

f. Skill Utilization and Continuing MOS Validation.

(1) After the technician has achieved journeyman status, CTS has little to do with his utilization except periodic MOS validation. The CTS course must be the basis of MOS validation, as it is the only measurable expression of the detailed technical skills involved. It is, or should be, the initial point where new equipment or techniques are introduced into the MOS. It should be the source of updating information or training material sent to the field. It follows, then, that the CTS should prepare MOS validation for journeymen in the field, whether it be a purely "go-no-go" qualification, or an evaluated validation, which seems more desirable.

(2) It would be even more desirable that periodic MOS validation be achieved "on line" at the service school, either by the physical presence of the technician, or by other means of access to the CTS computers and equipment.

g. Up-grading Skills.

(1) The technician, if he remains in the Army, must go "up or out." He must achieve higher levels of skill in his journeyman MOS, or he must pass to different MOS's using his original skill in addition to others learned by experience or additional formal training. CTS, as discussed so far, deals with individual MOS-producing courses. It is logical, however, that higher or broader skill MOS's can, in technical content, be derived by combining appropriate sections of several lower-skill CTS courses. Essentially, this creates another CTS course for screened and specially selected students. Feedback from the field, particularly that produced from continuing MOS validation would be essential in the construction of the higher-level course and the selection of those to be trained. For those who see inherent evil in "promotion by computer," those safeguards guaranteed by the subjective judgment of commanders are not threatened, as they are largely independent of the training system.

(2) At the higher levels of training, a great many follow-on actions are simplified. OJT, as such, need not be required. Only MOS validation from the technical standpoint, and feedback into the training system for evaluation and prediction are necessary. The technician is advancing to the supervisory level where broader and more subjective judgments determine his future.

h. Interrelationship of Training and Personnel Management.

(1) Previous paragraphs have alluded to information produced by the training system and utilized by personnel management at the highest Army level.

(2) Simply stated, the Army personnel managers must know:

- What technical skills are needed

- How many of each

- Where to put them

- When are they available

(3) CTS is not a candidate source for complete answers to those basic questions. CTS, however, does appear to be the only system in sight that includes functions capable of producing information to up-grade the Army's estimation of the answers.

(4) Factors beyond the Army's ability to influence do have large affect on its ability to answer the questions. However, accurate and timely prediction of the training system's output can provide a dramatic improvement to personnel management and save many millions of dollars.

(5) Basically, the Army should know, with the greatest possible accuracy: How many recruits, of what ability, must it take to produce x number of apprentice technicians at y time? It must know this for each skill it needs. In very gross terms, based on empirical data, the Army knows this now. However, the answer is unsatisfactory. Too many recruits are required, and stay too long in the training pipeline, and too few come out. Changing these factors beneficially could mean billions of dollars in eventual savings.

(6) It is believed that CTS can provide the following benefits, if properly exploited as a system touching on every aspect of the Army's training mission, and closely interrelated with personnel management:

- Refine aptitude standards for better prediction of success

- Determine the desirability of special aptitude tests for certain high-cost skills

- Improve the course content of skill prerequisite courses

- Predict and report at entry into skill course (CTS) probability of completion

- Predict and report within skill course, date of completion

- Recommend on an individual basis type and duration of OJT to unit commander

- Provide MOS validation at any time

- Predict skill up-grading potential of individual

- Construct combined high skill-level courses and resulting MOS validation

- Continue to evaluate and utilize data collected to improve and modify related training processes

i. CTS Applicability to General Knowledge Courses.

CTS can be used for general knowledge type courses (mathematics, para-professional legal or medical subjects, etc). The benefits, actual and potential, appear the same, particularly the evaluation and prediction functions. The advantages of self-pacing and individually prescribed remedials are obvious. The main question seems to be one of cost-effectiveness. If the general knowledge courses are vital to the Army's needs and those needs cannot be fulfilled by conventional methods in a timely and effective manner, then CTS would appear a strong candidate to perform the mission.

j. Applicability to Reserve and National Guard Training.

(1) CTS is certainly applicable to Reserve and National Guard training, provided those components use the same equipment as the active Army.

(2) CTS offers the following advantages to Reserve and National Guard training:

- Standardized training for all Army components using the same equipment

- The ability to insert new trainees into the program at any time

- The ability to pace the training to any schedule of trainee availability

- The potential for off-site training utilizing leased circuits for access to computer portions of the program. Reserve and National Guard training usually takes place at night and on weekends. This facilitiates the use of CTS computers and raises their cost effectiveness.

- The potential for increased effectiveness in the management of Reserve and National Guard training.

(3) One factor should not be overlooked. The National Guard, and to some lesser extent, the Reserve, are potent political forces. They have lambasted the active Army for years, claiming second-class status in training and equipment and with reason. Anything to improve this genuine imbalance would be not only a political help to the active Army but do much to improve the nation's military position.

k. Summary.

(1) CTS must be looked at as a part of the Army training system impacting on recruiting, training, utilization and management of technical specialists.

(2) Its benefits can be stifled if it is used only as a training method, even though it is a most effective training method. Its cost-effectiveness improves dramatically when its CMI aspects (data gathering, evaluation, prediction, self-improvement, etc.) are exploited. Its contributions to more precise management of scarce technical skill resources can be dramatic.

(3) All these benefits, however, can be derived only if it is developed and utilized as a dynamic system with all its functions interrelated, each affecting and being affected by the other.

(4) The analogy of the wheel in motion seems particularly appropriate. It is a dynamic structure, its progress determined by movement of its central number, with all other structural members continuously reacting with not only the central member but with each other.

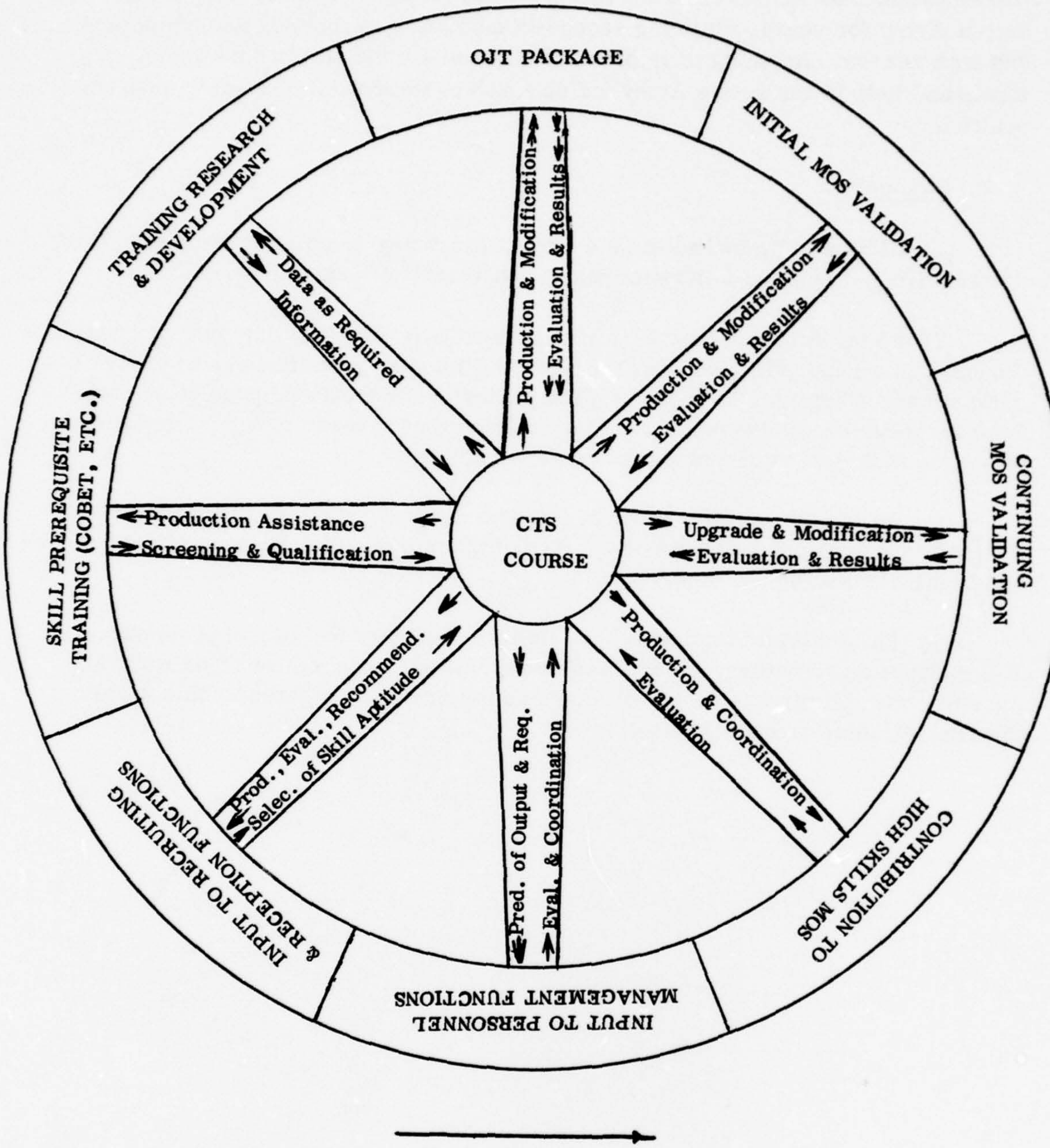

Figure 1. Technical skill, production and utilization.

Biographical Sketch

Harold E. Mitzel Ph. D.

EDUCATION

University of Wichita Wichita, Kansas	B. A., 1943 Magna cum Laude
University of Minnesota Minneapolis, Minnesota	M. A., 1950
University of Minnesota Minneapolis, Minnesota Major: Educational Psychology Minor: Psychology	Ph. D., 1952

EXPERIENCE

City University of New York	1952-1955	Asst. Prof. of Education
Office of Research & Evaluation	1955-1958	Acting Director
Division of Teacher Education	1958-1961	Assoc. Prof. & Director
	1961-1962	Professor and Director
Cornell University	Summer, 1962	Lecturer in Measurement & Statistics
The Pennsylvania State Univ.	1962-1971	Asst. Dean for Research
College of Education	1962	Professor of Psychology & Educational Psychology
	1971-Present	Assoc. Dean for Research
CENIDE - Ministry of Education and Science Madrid, Spain - UNESCO Mission	June 1973	Lecturer on Computer Assisted Instruction

TASK ORDER 75-129

Reactions and Suggestions on U. S. Army Computerized Training System

Harold E. Mitzel, Ph. D.
January 10, 1975

The purpose of this report is to respond to the invitation to comment on CTS which was extended to the Panel of Consultants. In the first section I will indicate some general impressions, mostly positive, based on the site visit at Fort Gordon, Georgia, December 7-8, 1974. In the second section I have tried to respond to selected questions posed to the Systems and Training Groups. In the final third section, I have made a recommendation for the future development of CTS.

General Impressions

a. This project seems to be essentially on its scheduled developmental track in spite of delays by the hardware and software supplier. I was favorably impressed with the Sylvania cathode-ray-tube terminal in relation to its cost. It does appear to have sufficient "bells and whistles" to interface the management of the three technical repair courses involved in the current effort. I would hope that the next generation of equipment would include an audio capability under program control. The cluster-plan for organizing the hardware configuration with its sharing of courseware storage is essentially sound and should yield minimal queuing and rapid response for students.

b. I was particularly impressed with the knowledgeability and dedication of the CTS staff, both civilian and uniformed. The morale of the staff seemed good at all levels, but was striking among the NCO's. They had obviously worked hard to bring the existing system up to its maximum potential for the consulting panel's review. They were well-acquainted with the features of the hardware and with the overall plan for CTS.

c. The evaluation plan for CTS needs to be mentioned in that the Consultant Panel spent a great deal of time discussing it with Mr. Longo. My general impression was that the Panel was highly critical of the evaluation plan. However, reviewing groups (particularly when made up of experts) frequently misunderstand planning efforts because they are unaware of crucial assumptions and key situational factors over which the evaluation planners have little or no control. After studying the Preliminary Evaluation Plan for CTS and taking into account the shift in location from Ft. Monmouth to Ft. Gordon with its attendant change in emphasis from CAI to CMI, I think the plan is basically a good one.

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d. It does seem to me that perhaps too great an expectation has been placed on the so-called summative evaluation. It is a mistake for the Army to make a global generalized decision about the potential of computers in training chiefly on the basis of the present effort. In the first place, this effort deals only with three specialized equipment repair courses. If one wished to generalize to the wide variety of training offered in the Army, one would need to carefully sample courses from some identifiable universe of courses for any evaluative effort to be generalizable. It seems patently obvious that computers applied to instruction are going to work better in some subject matter areas than in others. Secondly, a computerized course is complex and inevitably composed of many different elements. These elements are inextricably tied together as weighted causative factors in the measured output. Some of the factors which exert a potentially powerful influence on the overall quality of the output from CTS include:

(1) the pedagogical strategy employed by the instructional programmers (authors).

(2) the responsiveness and interactive speed of the terminals.

(3) the quality of the answer processing provided by the operating system.

(4) the mix of "on-line" and "off-line" instruction in relation to the aptitudes presented by the students.

(5) the attitudes of the instructors toward the computer-based materials.

(6) the preinstruction skills and abilities brought to the program by the sample batch of students.

e. A sound long-run strategy for the evaluation of computer based instruction is probably the method of limits. In this method, representative computer based courses are repeatedly recycled after collecting formative evaluation information at the end of each cycle. When successive revision cycles stop yielding gains in either achievement or reduced training time, then the evaluative process should be turned to questions of cost effectiveness. The base line for comparing the performance of computer mediated training then becomes the highest quality of hardware, software, and curriculum that can reasonably be achieved. Cost trade-offs involved in opting for cheaper hardware, fewer displays, thinner programming, less "on-line" time, etc. can then be studied analytically by comparing the cheaper abbreviated version with the maximally effective version. Characteristically, most summative evaluation is upside-down because the comparisons of an experimental method (e.g., CAI) are being made against some poorly defined, nonoptimized traditional method of instruction. Summative comparisons of the "horse-race" variety also suffer from the fact that costs of traditional programs have seldom been determined in advance and many of their actual costs are hidden in other categories.

f. In this connection the Army would be well advised to establish a small evaluation unit on computer based training that would look beyond the impending "go-no-go" decision for meeting Signal Corps training needs with CTS. Such a unit should be given the resources on a small scale to push the limits on instructional quality using a variety of criteria. The present evaluation effort for CTS, although a good one given the constraints of time and resources, is dealing with limited hardware, limited operating system, and a limited concept of the role of the computer in training.

Responses to Selected Questions

1. What type of major computer system for instruction is going to best fit the needs of the Army by 1980?

a. This is an extremely difficult question to answer because of the lack of history of using computers for instruction. Modern computing is only about 25 years old, and it is only in the last 15 years that any significant attention has been turned to the use of computers for instruction. At the moment, I think the nod from the field is going to the dedicated minicomputer either singly or in clusters, depending for the most part upon the size of the student body to be served. My own appraisal is that the system for the year 2000 is the large-scale dedicated processor with 500 to 1000 terminals. This guess is based on the anticipation of some new two-way communications links that will replace conventional telephone lines. The best candidate for such a replacement is Cable TV, where there appears to be sufficient circuitry to handle 250 interactive computer terminals on a single TV channel. There also seems to be plenty of room for computer-dedicated channels in the spectrum of TV wavelengths. The other assumption which leads me to believe that big systems will eventually win out over small systems has to do with the changing nature of pedagogy for training and instruction. As it is presently configured, most computer based instruction, whether CAI or CMI, is frame-oriented questioning followed by simple feedback to the student. It seems to me that computer based education of the future is going to have to provide for much more inquiry-oriented instruction in which the student can, with greater independence than he presently enjoys, query a large data base of information relative to specific subjects of instruction. If true, then operating systems of the future will have to provide for sophisticated retrieval mechanisms from large complex data bases. Present configurations of minicomputers just don't have enough "muscle" to handle this changed concept of instructional method.

b. Another factor which offers some food for thought and could affect hardware requirements is the notion of individualized objectives for different students. This concept will probably be implemented in civilian colleges and prep schools before it reaches the Army's training command, but it is not unthinkable at the higher levels of training in the armed forces to have different sets of objectives for different trainees. The force of this development would, in the context of computer based education, be to highlight the need for large data bases and large record-keeping capabilities with rapid retrieval. Individualization at the level of objectives would increase the requirements for sophisticated diagnosis.

c. A third factor arguing for large computer based systems is the need for uniformity in a highly mobile world. Trainees often shift from one location to another and it is wasteful of training time to have students repeat segments of training courses because of minor variations in courses offered at different locations. It is much easier to modify and update a single master version of a course of study on a large system than it is to modify slightly the same course at 20 different locations.

d. A fourth press toward large regional systems comes from a growth factor. At present time, CAI and CMI development are focused on individual courses. After some growth, assuming continued success in performance, our concern will be with programs of instruction involving higher and higher levels of instruction for the soldier/student. When we get to the instruction program management level we will necessarily want to collate pedagogical information about the student from different courses. The advantages of large systems with resident data bases of student records from learning histories in multiple courses are obvious.

2. What new terminal hardware is on the horizon that could open up training opportunities?

a. Unfortunately this question is all bound up with costs. Whereas major decreases in cost for central processors have resulted from breakthroughs in technology, no such impressive cost reductions are apparently in the offing for terminal gear. A complete student station for an IBM 1500 system (circa 1968) costs about $10,500. A complete student station for the newer PLATO system (circa 1972), based on a new plasma display technology, costs about $9,000.

b. I believe there is a bright future in training and education for special simulation apparatus, but that future is going to be deferred for at least two decades.

3. What problems can be expected if existing (planned) courseware were to be converted for use on the next generation system (beyond ABACUS)?

There won't be serious problems as long as the expectations for CTS remain with a frame-oriented pedagogy in the case of CAI or with a CMI "off-line" study concept. In my opinion, the next generation of support hardware should clearly be constructed with a different kind of pedagogy in the offing. Not much is known today about the requirements of a computer-mediated inquiry system of instruction.

To my knowledge no one has built a system of this type with a reasonably adequate data base. There is, however, reason to believe that they will be built in the future. If inquiry systems can be made to function effectively, then they hold great promise of extending Man's powers of reasoning, problem-solving, estimating, and anticipating.

4. How can courseware development be organized so as to increase timeliness and/or reduce costs without reducing quality?

Courseware development does seem to be the major "hang-up" of contemporary computer based systems. The TICCIT effort has approached the problem by narrowing its pedagogical strategies to a "rule-example" application. In spite of this efficiency-producing strategy, its courseware production has been badly delayed. The lack of sizeable blocks of integrated courseware has been seen at the major weakness of the PLATO effort. Both TICCIT and PLATO are being funded by the National Science Foundation.

5. To what extent must hardware/software/courseware be standardized to achieve transportability of courseware?

It may not be obvious to executive decision-makers in the Army that the key to this problem is hardware. If CAI terminals at the several separate training installations are maximized with respect to pedagogical functions (e.g., include audio display), then "downward" compatibility will be almost automatically achieved (i.e., courses constructed without audio displays can be accommodated at terminals with audio capability). However, the reverse situation presents an impossible problem. Terminals are almost never "upward" compatible (e.g., you can't "run" an audio-imbedded course on a terminal that has no audio display device). The latter situation most often arises from misguided attempts to save money on terminal gear by installing only lean function equipment. Civilian experience with the transportability problem shows without doubt that it is serious, and careful planning is needed to avoid its bad effects on computerized training.

6. To what extent would the introduction of CMI (in Army training) enhance learning?

a. A program of computer managed instruction (CMI) has a big initial advantage over traditional instruction because the method forces course authors to be clear and explicit about their objectives. Modularized lessons from that point on offer some small advantage because of the self-pacing function. Generally, however, CMI courses are not very good at meeting the needs of individual learners. Materials of instruction used in CMI settings ("off-line") are by and large the same for everyone, and it is a mistake to expect great achievement gains from CMI in contrast with traditional instruction merely on the basis of the fact that a computer is involved in record-keeping and feedback to the student.

b. It is in this connection that a significant advance in training outcomes can be made by developing an appropriate mix between CMI and CAI. For some inefficient learners (poor study skills, inadequate reading ability, and minimal motivation), materials employing CAI formats may be a solution for the chronic "wash-out" or program repeater. CAI offers considerable advantage if sufficient diagnosis and remediation can be built into the "on-line" materials. Depending upon the goals of the student body, the courses in the CTS program, and the range of aptitudes of the students, I would think that an appropriate mix of CMI and CAI would yield a good return on the investment. Where time in a course is a premium criterion, the ablest students can probably achieve satisfactorily with CMI materials. Such a plan saves time-on-terminal for the less able student in CAI mode.

Recommendations for Future CTS Long-Range Developments

a. It seems to me that the Army is in a good position to improve the quality of its enlistments by using computerized instruction rather widely in its training program. An integrated Army-wide computer based training program could be augmented by offering recruits an opportunity to complete the first two years of college (60 semester hours). The rapid growth of junior and community colleges during the last two decades attests to the expanding interest of young adults in postsecondary education.

b. As I envision it, approximately 20 college-level courses on such subjects as history, sociology, philosophy, mathematics, physics, chemistry, biology, psychology, business statistics, accounting and English could be offered to recruits during off-duty hours at training installations and in operational units by means of an Army-operated CAI system. The program would require curriculum development by a consortium of major universities geographically spread across the country. If their faculties developed the courses, then the members of the collegiate consortium should have no qualms about granting academic credit to soldier/students at the close of their enlistments or of accepting such students into upper-division programs.

c. Working at a normal pace, students could be expected to complete a 3-credit lower-division course in 30 to 40 clock hours. This means that 20 courses could be completed in 600-800 clock hours. If a two-year hitch had at least 60-80 productive weeks, then a soldier/student would require only about 10 hours per week of his off-duty time to complete freshman and sophomore years of collegiate instruction. Of course, not everything in college can be learned on a computer, but there would seem to be no hesitancy to grant civilian physical education credits for the supervised physical fitness program characteristic of Army training.

d. This program would attract the able but indigent student who has been reluctant to join the Army because it would set back his plans to earn the baccalaureate degree. The program would also provide an automatic screening for future officer candidate school classes.

e. The investment required to mount de novo this plan at U. S. Army installations at home and abroad would be sizeable. However, if the Army is going to computerize its own training program, it would require relatively little additional systems capacity to add on the first two years of collegiate level instruction. With success in the lower-division college courses, it should be a relatively simple step to the integration of other types of postsecondary vocational training into a joint Army/Civilian program of instruction.

Biographical Sketch

Catherine E. Morgan

Catherine E. Morgan is currently Director, Computer-Assisted Instruction Program, Montgomery County (Maryland) Public Schools. Prior to assuming these responsibilities, Mrs. Morgan spent 2-1/2 years as a CAI curriculum author and has designed and developed numerous individualized learning modules in secondary mathematics. In addition, she has been instrumental in the conduction of teacher training programs in educational technology at the public school level and has given numerous presentations on instructional technology and CAI at national and regional conferences of professional associations. Mrs. Morgan was a secondary mathematics teacher for ten years. She received both her B. A. and M. Ed. in Math Education from the University of Maryland.

Task Order 75-63

Recommendations Relative to Medium-and Long-Range Plans to Improve the Army's Computer Training System

by

Catherine E. Morgan
January 1975

The Army has an extensive and continuous training program and is investigating the optimal manner of incorporating computer and instructional technology into its educational efforts. To meet this objective a report is to be prepared which reflects the experiences and opinions of civilian, Army and other government specialists from the field of computer managed and computer assisted instruction. This report will cover both short- and long-term plans for improving the development, use and evaluation of the computer based instructional systems in the Army.

Background

a. Project ABACUS, having as its background the Fort Monmouth experiences in CAI, has transferred its operation to Fort Gordon, Georgia. The conference held at Fort Gordon on December 7-8, 1974 provided to the participants the updated information on which this report is based. Some marked differences in the project were apparent from the on-site visit. Among these is the obvious change in physical location which involves concommitant changes in personnel and environment, but far more important is the change in direction from CAI to CMI and the concentration in three training courses in which development and use had not been experienced previously.

b. The principal deterent to making judgments relative to the curricular materials and the hardware system to be implemented is the lack of an interactive mode due to the current software difficulties.

Assumptions

a. The writer of this report assumes that the software problems will be solved and that the interactive network will be operational during the next few months. However, CTS will not have sufficient time to pilot-test the materials with students, make the necessary revisions and validate them prior to the time specified as the end of the project. It is hoped that the recommendation made at the on-site conference is adopted--to delay the evaluation date by a large enough time factor to provide more meaningful data and experiences upon which to make decisions.

b. It is further assumed after reading some Army prepared manuals relative to training materials that course development (not only CAI/CMI) generally follows the tenets of instructional technology, including task analysis, writing objectives and criterion items, constructing hierarchies and determining instructional strategies.

c. Observations and discussions show that the Army, Navy and Air Force have an interest in CAI/CMI systems, that each service is involved to some degree and that there is a loose connection among them. It is assumed that this connection is fairly informal and that each is not influenced to any great extent by the others.

d. The last assumption made by the writer is that the United States Army will continue to be involved in computer based instructional technology.

Discussion

The experiences of the author have been in the field of computer based instructional systems for six years; first, as an author-developer of course materials and for the last four years as the director of a computer assisted instruction program in a large public school system. The strengths of this CAI program have been in the development of curriculum, training of course authors and users, implementation into the classroom and in evaluation. Therefore, all of the following discussion has been restricted to these areas.

Training for Course-Authors and Course-Users

a. Experience has shown that the implementation of already developed and validated CAI/CMI courseware into the regular instructional process requires some unique skills and these can be acquired by instructors through training courses. This type of course is distinctly different from that required to train course-developers and obviously requires considerably less time. Therefore, each CAI installation will need to develop both types of courses.

b. In the initial choice of individuals for training to be CAI/CMI developers, the most important characteristics should be successful experience in teaching the courses to the types of students with whom the new technology will be used and a proven interest in the individualization of instruction based on student needs. It is unrealistic to expect that all those who are trained will be successful as developers of CAI/CMI materials. During an intensive training course which would include all aspects of design and development, each participant should author a modular instructional package which would be critiqued on each area of instructional technology following the presentation of the topic in class. Like most first efforts in any new field, it is unlikely that this product would ever be used, but an examination should reveal whether the person has some talent for the field.

c. With the realization that the Army has unique training requirements and wishes to develop a particular philosophy with its students, the objectives of all courses will have some common denominators. With this in mind, the Army may wish to develop and run its own training courses for authors and users in spite of some excellent university offerings. The Army has, in addition, another deterrent to true individualization -- the rigid limitation on maximum course time. This timetable concept may be incompatible with the specification that solders may now pursue the occupational specialty of their choice.

d. Characteristics of superior author-developers should include mastery of course design objectives which require skill in logic, test construction and flow-charting and, in addition, in development procedures which require creativity and writing skills. Individuals who possess this expertise should also be able to work a member of a design team and to work independently as the situation dictates. It is essential that developers have sufficient time and experience to pilot-test and validate their instructional materials. In addition, organizations should run training courses on a fairly regular basis so there exists a cadre of trained people from which new authors can be drawn.

e. The development of a shorter training course for users of CAI/CMI materials is essential. These individuals need to be informed about their roles in a changed environment. To fill this role, they must understand how the curriculum was developed and be provided with complete written documentation relative to the objectives, assessment items, hierarchies and strategies of each course. Further, they should interact with the computerized instructional programs at the computer terminals in the same way as their students will. Although the skills required are not radically different from those needed by an innovative classroom teacher, instructors in the new environment will be receiving a plethora of up-to-date information of a diagnostic nature. Their new role will include reading and interpreting this computer feedback, further diagnosing student needs and providing direction or remedial help where necessary. The scheduling of student time will also be the responsibility of the instructor if the computer management program does not provide for this function.

<u>CAI/CMI Course Development</u>

a. The first step in course development should be the determination of need. In the case of computer based instruction this is essential, as need here means not only is the instruction necessary but that other methods will not work. The Army should conduct research, study its records, obtain questionnaires and discuss with those in the field to determine the areas in which:

(1) The largest number of deficiencies are documented or observed following training;

(2) The most extensive need for re-education at some later date is recorded;

(3) A number of indivuduals need a particular skill and that skill is required in widely separated geographical areas--the number is not large enough to conduct a class; and

(4) Course revisions of a somewhat limited character need to be made frequently.

b. Only after this data is obtained and analyzed showing that the present methods are ineffective, inefficient and/or costly should CAI/CMI be considered. As cost is considered in any course, the simplicity of revision in CAI/CMI courses is a tremendous asset.

c. As any organization who has attempted individual instruction has discovered, the Army has determined that the most difficult aspect of individualization is the assessing and monitoring student progress through the courses. It is, therefore, obvious that a generally applicable computer managed instructional paradigm should be developed and tested following the conclusion of the ABACUS Project and integrating the positive features of that model. From the records of students enrolled in such a CMI mode, information on specific individual and group needs will be obtained. This data should be carefully examined and the recurring trouble areas in the courses be identified. Each trouble area should be carefully analyzed and the determination of a solution should entail a close look at the possibility of developing a CAI module. This development effort could, in turn, become one of the prescriptions in the overall CMI system.

d. The author's experience has shown that it is impractical and indefensible to develop entire courses in CMI mode. Every course requires a variety of types of presentations, i.e. reading materials, group discussions, motivational films, lectures and practical hands-on experiences. To assume that these can all be replaced by computer presentation is unrealistic. However, drill materials with immediate feedback, interactive tutorials, diagnostic testing and simulations are excellent vehicles for individual learning and tying these CAI techniques to need situations solves some very sticky instructional problems. Another plus for the modular approach in the public schools has been the utilization of the materials over a number of grades and in a number of subject areas. It would appear that this same situation occurs in Army training courses. A student may need to master certain basics in arithmetic, algebra and trigonometry for many courses. If CAI modules exist or are developed, they can obviously be used as segments of many courses.

e. Army trainees are for the most part former public school students. As such, they reflect both the successes and failures of public school education. These varying results are most striking in the areas of reading comprehension and vocabulary which, in turn affect all future training and education.

f. In the preparation of materials, one Army author-developer stated that he used the same language in the textual displays as that spoken in the classroom. This approach is satisfactory for excellent readers as they comprehend more complex and technical written materials than they could possibly attend to in oral communication. However with less able readers, the opposite situation exists. These students cannot comprehend the written language at the same level of complexity as they can the oral language.

g. Therefore curricular materials which are to be read both on the visual computer display and in printed form should be analyzed for readability levels. The analysis should include scores for both comprehension and vocabulary difficulty. The essential course vocabulary will obviously be eliminated from any readability analysis as these new technical and other related words and expressions are integral to the course and will be taught prior to their use. There is no intention to water down the course content but to look realistically at the students' past achievement in reading. A student's instructional reading level is the level in which new reading skills are acquired, while his independent reading level is the one in which he uses previously acquired skills. Optimal instructional situations in other subjects than reading make provision so that textual materials are available at the student's independent reading level. If the Army accepts trainees whose achievement in reading is below the tenth grade, it needs to provide instruction in specialties in a way that students have a realistic chance for success. It is important in this connection to examine and rate all Army training manuals related to the courses, especially those used in the field for updating or retraining purposes. In addition, the Army should prepare or acquire instructional materials and systems to teach and improve reading achievement.

Evaluation

The evaluation plan for a computer based instructional system and network will encompass its instructional, technical and cost features. However, the ultimate decision related to instruction should be made on the effectiveness and efficiency of learning which implies optimum technical support. Cost figures on a research and development project do not reflect the generalizability of curriculum use for other populations which may ultimately make the system cost-affordable. Therefore, prime emphasis in Project ABACUS should be placed on the aspects of educational evaluation. The curriculum materials should be judged on their validity, their efficiency, their acceptability and their effectiveness. In addition, full credit for course improvement and sequence validity should be given to the system.

Recommendations

The following recommendations are made with the objective of aiding the Army in making medium and long-range plans for its Computer Training System:

a. The Army should work closely with the other two services in all aspects of computer based instruction, and particularly in the preparation of curriculum and the specifications for future hardware and software. A concerted effort should be made to identify common needs, share curriculum and conduct comparative studies on the shared materials.

b. The Army should establish a central site for curriculum development. At this location, courses should be held at regular scheduled intervals for both author-developers and instructor-users of computer based systems. From the resultant cadre of trained individuals, every effort should be made to retain the services of effective course-authors and prevent transfers to other unrelated Army assignments.

c. The Army should score all textual materials for readability level. These readability scales would not include new technical works and expressions essential to learning the specialty. This analysis would obviously use one of the recognized scaling devices which takes into account length and complexity of sentences.

d. The Army should prepare a generally applicable model for a computer managed instructional system. Inputs should include results from Project ABACUS and from successful programs elsewhere throughout the country.

e. The Army should begin now to conduct a number of long-range research projects which will provide essential information relative to retention, need for retraining and efficiency in the field. Questionnaires and information sheets should be disseminated to National Guard and ROTC units to determine their needs for training and how CAI/CMI can assist them in meeting these needs.

f. As new evaluation plans are formulated, the Army should evaluate each CAI/CMI effort with a detailed profile on a group of randomly selected students to ascertain the correlation of success with reading level, aptitude and achievement, including in each course, a small number of students who can join the Army personnel pipeline on a flexible basis.

g. The Army should develop at least one individualized course in which individual learning styles are considered. This effort might determine that for some students a more traditional approach with its related cheaper cost is most efficient.

h. The Army should prepare and make available CAI/CMI courses for field retraining, ROTC and the National Guard.

i. The Army should determine where terminals are available in public and private institutions which can be leased evenings, weekends, and during school vacations. Then these terminals could be made available for ROTC, National Guard and the regular Army in cities across the country and abroad.

j. The Army should plan to place terminals in strategic locations within Army installations to curtail travel time and the obvious related subsistence allowances required when personnel are away from their home base.

k. Working closely with education, governmental and military institutions, the Army should begin to set the groundwork for the eventual standardization of one or more instructional languages.

Conclusions

a. The Army continues to make a substantial contribution to the field of computer based instruction. Project ABACUS is a prime example of an effort which encompasses all aspects of the field from development of specification for equipment and language through the evaluation phase.

b. The commonality of Army, Navy and Air Force requirements would suggest that the three services work closely on CAI/CMI course development, share materials and evaluate each other's products. Not only could sharing be done among the services but also in situations where it has been determined to be mutually advantageous, with public and private educational institutions. It would appear that the sharing of curriculum by many organizations would enhance the state-of-the-art in spite of the present hardware and software incompatabilities.

c. Although the expansion of CAI/CMI systems has not moved as quickly as was predicted during the 1960's, interest in the mid-seventies is at an all-time high. There is a growing awareness that this technology may be the only way to solve certain educational problems. The cost factor has not decreased as rapidly as had been hoped. However, with the high interest in development and implementation of curriculum and the new technologies on the horizon, the author predicts that costs will dramatically decrease and by the mid-eighties, large numbers of computer terminals will be found in all educational institutions and in many private homes. Therefore, it is essential that those in the field continue to struggle and proselytize. Without these continuing experiences, the Army will not have the required expertise to utilize the technology.

Biographical Sketch

Thomas C. O'Sullivan

EDUCATION

Psychology, Cornell University
M. S. Antioch, Putney Graduate School of Education
Miscellaneous courses -- Math, Computer Science

EXPERIENCE

1973 - Present — ADVANCED RESEARCH PROJECTS AGENCY
Program Manager for Advanced Training Technology; responsible for developing a program of research to advance training technology for application to the training requirements of the Department of Defense.

1962-1973 — RAYTHEON COMPANY
As systems engineer, defined detailed specifications and technical approaches for Raytheon version of FAA's en-route air traffic control back-up system. Developed Raytheon Data Systems Co (RDS) data center in support of Software Development and Operations and installed software distribution and troubleshooting activities; closed out Santa Ana programming and computer center transferring necessary capabilities to Norwood/RDS; served on Operations Integration Staff at Equipment Division Headquarters with varying responsibilities including business systems and programming, computer operations, and scientific applications; chaired committee for ARPA computer network communication protocol for keyboard terminals under ARPA study contract. Directed projects including contract studies for DoD and State Department on the Role of the ICBM Under Arms Control, concepts of Advanced Sea Based Deterrants, and Progressive Zonal-Inspection of Disarmament.

1958-1962 — ITEK CORPORATION
As Administrative Assistant to Director of Research, later as Staff to Chief Scientist, participated in projects involving information systems for libraries and reconnaisance applications.

1946-1958 — Various assignments for Southern States Cooperative, National Advertising Company and United World Federalists.

REPORT NO. 1

The Transfer From Lab to Field of Training Research Results

by

Mr. Thomas O'Sullivan

a. A key problem in training is the effective use in the field of the results of training research. The problem is of concern to congressional staff, OMB, DDR&E, and each of the Services (in both the research and training commands).

b. The concern is reflected not only in discussions but also in the focus of special study panels, and the establishment of procedures to document "transfer" history.

c. The Services have been providing mechanisms to facilitate the transfer of advanced training technology to the commands. In the Navy, the Navy Instructional Technology Development Center, a CNET organization in San Diego, has been working closely with several of the Navy schools to introduce some recent advances in training technology into new curriculum. At Fort Monmouth, staff members of Project ABACUS, of which the Computerized Training System (CTS) is a part, have been searching for recent advances that will improve training in the Army.

d. There is a class of research being performed in and for the Service laboratories dealing with the pedagogical issues in training important in the context of curriculum design decisions. This type of research deals with issues of: what strategy to use given the type course and nature of the student population; criterion for selecting and mixing presentation media; appropriate instruments for individualization of instruction; definition of data to be collected to support decisions on redesigning or modifying the course, etc. Transfer mechanism for this class of research seem weak.

e. Discussions about the problem suggest that failure to use the research results may be attributable to a number of reasons. Often the research results are ambigious. The less ambigious results are generally demonstrated in a tightly controlled experiment with specified assumptions and regulated conditions, not within the context of a total training environment. Researchers have difficulty pushing the concepts into the field and must settle for "publishing" the results. Some curriculum implementors feel the research speaks to the wrong problems but many, faced with delivery deadlines, say they fail to use new techniques because of lack of knowledge or time, and stick with the older "tried" methods with which they feel comfortable. In effect, the new concept has not been field tested and proven in a full training environment. Training command personnel are not familiar with the concepts. There is no formal mechanism to provide for such tests on a regular basis.

f. In spite of this, many ad-hoc attempts at transfer have been successful. It seems reasonable to expect that if there were a formal mechanism to provide for full field test of the laboratory proven research result then doubt would be put to rest, one way or another, and more transfer would take place.

g. A lab school, providing for such field tests in the civil sector implies a well staffed, full function school handling a body of curriculum with real students. The students may represent a particular set or mix of socio-economic background. The school's purpose is usually for the experimental introduction of new procedures or curriculum or special situations with observation and evaluation of the effects. Access to the school is provided to an academic department or a special project or program staff.

h. The military correlate to a lab school would be similar. It implies location at a training command school with appropriate student flow and with selectively developed exemplary curriculum in a number of different courses to provide an advanced baseline for work with different kinds of students and different kinds of course material (i.e., different mixes of cognitive, procedural and psychomotor skill content). Access to the school and its curriculum and student flow should be provided to military training research laboratories and their contractors, under controlled conditions, to perform systematic experimentation on issues relevant to curriculum design and implementation.

i. In order to support the exemplary cirriculum and the experimentation, the lab school must be equipped with advanced hardware including: computer managed instruction (CMI), computer aided instruction (CAI), special computer controlled devices (carrels, slide/tape, cassette/film displays, TV/tape, generalized simulators, etc.). In addition, special test and measurement implementation staff is needed to support the research efforts, and access must be provided to the researchers for purposes of curriculum modification.

j. In the ARPA/Joint Services field tests of the PLATO system at Aberdeen, Shepherd, Chanute, and San Diego, it was hoped that the terminals at each school would be used to establish laboratories in which research results from the lab could be checked out in the context of a full training environment. The situation seemed ideal. There would be curriculum in place, and a flow of students available for systematic variance of presentation and selection of experimental and control groups. However, there are no signs to date that this transition will take place.

k. The Air Force AIS system in development at Lowry has the potential for becoming the hub of an experimental or laboratory school. Since the primary thrust is to provide Computer Managed Instruction (CMI) capability and demonstrate the effectiveness of CMI for different kinds of curriculum, it will have the capability of gathering test data on mixed-media presentations of course materials.

While there is talk of putting some Computer Aided Instruction (CAI) material up on the AIS there is no firm plan to do so, and while there is hope, there is no firm indication that any of the clusters of terminals will be set up in a formal laboratory school of the type indicated above.

l. The Navy research personnel at San Diego identified the requirement for such a lab school and have laid out detailed plans for its implementation, however, the plans have not as yet been approved.

m. The Army CTS project has the potential for providing such a lab school environment. It has the CAI/CMI orientation needed for such an operation. While it is currently a single-terminal-type system, it has the capability of handling multiple types of student and instructor input and output devices. Its structure allows for easy access by researchers to curriculum for purposes of modification. Each of these areas will be discussed.

n. The CTS system provides a student record block with a majority of the record available for use by the instructor/designer. This fixed size record should provide sufficient space to collect the necessary data for most experiments. In cases where this is not true, it should be possible, with little effort, to provide for links to "extended" student record fields in both the terminal driver where the data is collected and in the main processor where the records are processed both by the system and by application programs. There may be situations in which the CMI function is substantial enough to require substantial computer capacity but this is likely to be between student sessions. If not, then the experimental design should be examined to see if the function can be provided in a different way, or a link provided to a more powerful system (such as the Air Force AIS) in real time to complement the CTS capacity.

o. The system architecture provides for separate terminal drivers for each terminal cluster. Present design calls for a single-terminal type. However, with a reprogramming of the terminal drivers other devices could be supported. For example, a recent design study supported by ARPA and executed by SOFTEC of Waltham, Massachusetts, shows that PDP 11's can be programmed to handle the TUTOR language author sub-set of code to drive PLATO terminals. The study shows that the software development will be expensive but if the conventions of lesson storage and student-record data are followed, PLATO course materials could be supported on one terminal cluster of a CTS system. Similarly, other terminals could be supported in addition to specially designed computer driven multi-device student carrels. One terminal driver could be configured to swap in special software drivers from the local disk along with student lesson material to accommodate currently undefined student interface devices, both input and output.

p. CTS staff have been exploring the design requirements to allow the system to support both remote terminals, and remote clusters including the terminal driver. If both of these capabilities are implemented, then the flexibility of the system will improve substantially. Researchers/authors will be able to access the author support capability of CTS from geographically distributed sites permitting Service research labs and their contractors to access curriculum materials, modify them, and check them out in preparation for an experiment. At a modest level, researchers could perform lab based (as opposed to school based) experiments prior to release of the new materials to the school.

q. The administrative organization of the lab school presents some interesting problems. Certainly the activity could be centrally administered and controlled. That is the school where the laboratory is located or a single organization there could have complete control of all functions. However, this could tend to dampen broad and flexible use of the system. The functional distribution of responsibility and authority, carefully separated, could encourage maximum use of the facility as a research resource and as a transfer device.

r. From a logical standpoint, the administration of the lab school system breaks into three areas:

Course Administration
Computer & Device Center Administration
Research Administration

s. It appears that from a functional standpoint this breakout is clean and clusters like activities together under separate specialized groups.

t. Course administration is classically a school responsibility and under the proposed lab school plan would remain so. With respect to the courses for which exemplary base line curriculum is developed, they would be an integral part of the responsibility of that school's staff and its commander, instructor and administrative staff would be provided through normal channels. This allows the school's command to systematically expose personnel to the new techniques and technology used in the course. The problem of scheduling, base logistics, and billeting at which schools have to be proficient would remain with the school. It may be that the courses are distributed across a number of schools in order to get the right mix of type of student and type of course.

u. Courses into which advanced technologies have been incorporating incorporated have special problems. The computer, its terminals, communications, and special devices require specialized knowledge to keep them available on a stable basis. Their acquisition, storage, operation, issuances, maintenance, and service will probably require the formation of a special group. At least a special branch of an existing group such as the computer center if appropriate, or audio visual device center, etc. The course administrator should not have to cope with the standard service groups on base, but have access to the specialized group who have the knowledge and motivation necessary to provide direct service, or the clout needed to act as expeditor for the course administrators as student population changes, class locations are changed, equipment fails, etc.

v. Research administration can be a third discrete component of the operation and is probably made up principally of a lightly staffed committee. It will have the responsibility of screening applications to conduct research in the lab school, select between competing requirements for the lab resource, schedule the experiments so as to not permit interference between proposed projects, and protect the interests of the school and its students. Thus, while the primary representation on this steering committee should be from the Service research laboratories who, together with their contractors, are making use of the lab school, there should be representation from the school command, and the administration of the relevant course who should have virtual veto power to reject proposed experiments that seem unjustified or dangerous to the students. The staff should support the steering committee but report to an executive committee with representation from the training and research commands with the authority to rule over disputed issues.

w. This paper has begged the issue of course selection and the development of exemplary curriculum. If the lab school is to be made available to other services for research purposes then the selection and design should be done by a tri-service task group with background in training research in each of the Services.

x. The establishment of a formal test bed in the operational Training Command to provide a controlled, but real, training environment to use in testing newly lab proven techniques in a formal course with constant student flow, would provide several advantages.

(1) Give a fair full test of the research concept.

(2) Introduce Training Command personnel directly to the techniques.

(3) Relieve the research community of the burden of running "lab schools".

(4) Relieve Training Commands from the burden of providing test environments on an ad-hoc basis.

y. If the proposed lab school is to be established, it should be done on an evolutionary basis. The basic CTS design seems to be flexible enough to support the activities described above. It must now be proven that the design works. In selecting options for implementation under the design, special care must be taken in the design of the data collection and reduction packages so that the CMI section is powerful enough to support a lab school operation.

REPORT NO. 2
The Delivery of Job Related Information to the Specialist

by

Mr. Thomas O'Sullivan

a. Formal school based technical training, at the specialist entry level, is the beginning of a series of operations involving the delivery of job related information, in which the specialist will be involved for the rest of his work career. The series of operations, if evaluated and planned as a system within the boundaries of advanced technology can provide better performance, and therefore readiness, at lower cost. Thus, the Army CTS could prove to be an effective tool within the context of formal school based training and extend its impact to operational bases.

b. This paper will touch on some of the key issues and advantages in an overall delivery system view, as defined above, in formal school training, formal on base training, on the job training, the management of daily task assignments to reinforce training, proficiency maintenance, and job performance aids.

c. The potential for using advanced technology to deliver and manage individualized instruction, and realize some of the savings attendant to the process is well known. Much less is known about how to integrate the management across mixed media and forms of delivery that employ automated and semi-automated techniques. However, the Navy funded work at the University of Illinois on the CAMUS project showed success in managing students through the study of economics by directing students, on an individualized basis, to various learning resources. When we are able to apply these techniques to courses where instructor involvement has been minimized, we should be able to transport the technology from the school to the operational base, reducing the school residency time requirements for the courses involved and benefit from the attendant savings. CTS as a delivery and management system can play an important role in this transition. Early experiments in the Air Force with a generalized simulator, in the Navy with dockside training, and in the Army with UTEC II show promise for moving in this direction more rapidly by providing new insight into the control of the training process and new technology for direct presentation of training materials and experiences.

d. The shift of more training away from the school to the operational base will not permit a reduction in manpower. There will be more men on base but each man will spend less time on operational tasks. The base commander must take care to insure that the formal training time is not an extra duty but a part of the men's normal duty day. The advantage of having the extra manpower is that in time of emergency readiness is higher, since the men are already integrated into the base operations. This form of training should not be considered on the job training. It is formal school-like training and this mode is similar to work-study programs in the civil sector.

e. The course at Sheppard Air Force Base for Physician's Assistant is a two year program. The first year is spent as a resident student at the school with 1000 hours plus of student contact. The student also has "hand-on" experience at local military medical facilities. The second year is spent in on the job training at the Air Force medical facility to which the trainee is assigned.

f. The first year curriculum is currently being revised. A substantial portion is being put up on PLATO. If the course were put under Advanced Instructional System management control, using CAMUS techniques and the portions not amenable to CAI were presented through UTEC II and other such devices, instructor load could be minimized. It is possible that through a reorganization of the ordering of the course elements that a substantial portion of the first could be transferred to the station to which the student is to be transferred for his second year by establishing a learning center there with the necessary equipment and materials. Lab experience at the school could be minimized and replaced with on the job training at the new station. If that station does not have the appropriate laboratory, then there is question as to whether the trainee should be given the same lab experience as those who will be stationed at a location where those lab facilities are available.

g. The shortening of the school residency time and lengthening of the second period, changing it to a work-study program would result in placing useful personnel, with a specialty in short supply, at operational facilities ready to move into action in cases of medical emergency.

h. Although on the job training already takes place on operational bases for many MOS's, the author has seen little evidence that it is being effectively executed, and often its implementation varies broadly as a function of the supervisors' ability and interest. The addition of CMI to present formal criterion-referenced testing and to collect actual performance data could lead to a more consistently high level of achievement for students in on the job training programs. In addition, the test and performance data in the CMI system could be used to generate guidelines in the form of preferred priority listings matching trainees to the day to day task assignments to make most effective use of the work day in strengthening trainees in their weak areas of knowledge and performance and in spotting where formal training or other remediation is needed.

i. For example, if recently trained auto mechanics are given an on the job training assignment, and their day to day assignments are placed under

CMI control, the exposure to different kinds of experience could be balanced across the trainee group. When the level of exposure to a particular type of work experience drops below a prescribed threshold, the trainee could be tested in that area to determine whether or not he should be exposed to a simulation or other drill and practice exercise. Similarly, if the measured performance of the trainee falls below a threshold for his level of training and experience, then remedial action could be prescribed.

j. The same kind of test and management system for daily assignments should benefit the experienced specialist as well. Whether it is used to systematically expose the experienced man to knowledge and procedures to reinforce prior learning and experience, or to prepare him for a specific new assignment, these techniques should reduce the requirement for formal proficiency maintenance programs.

k. If the system notes that an experienced electronics technician has not, in his normal work experience, been exposed for some time to a particular problem or procedure, the task list of outstanding work could be scanned. If that type task is found, the technician could be placed on the list of preferred workers for that task. This could be used as a guideline but not acted on by the supervisor. However if the technician is bypassed too often then the situation could be flagged, and the situation examined to determine if there is special reason for lack of response. When the technician does perform against the assignment, measurement of the quality of the work could be measured to determine if remedial action should be prescribed.

l. Even though reduced, the residual proficiency maintenance program can be improved at low cost, assuming that formal training has been individualized and is automated or semi-automated. Because of the individualization, the exposure to materials for proficiency maintenance should be able to be supported by the formal course materials. Through the testing, the specialist will be guided through only those materials he needs. This coupled with the daily task scheduling system should provide adequate review for proficiency maintenance.

m. The system of information delivery is complex but lends itself to two formal models of the process and the relationship between the components. It could be either developed on a technology base across systems, or on a system life cycle base across technologies.

n. The analysis for the technology based model could start by looking at the key or critical skills involved in base maintenance operations, and back off through the key components of the information system for each base function or weapon system.

o. If the skill selected were vehicle maintenance, then the use of that skill would be examined for the whole base or operational unit on that base for preventative maintenance, field maintenance, and garage or shop for vehicle and shop or depot for parts rebuilding or repair. The model should identify the knowledge and ability required for each operation to be performed and the normal progression of the specialists growth through the system for specific weapons systems and base functions.

p. The analysis for the weapons system based model could start with a major weapons system, identifying the critical skills necessary through the life cycle of the system for maintenance and/or operations, then back off through the key components of information delivery for each skill or technology.

q. If the system selected were a ground to air missile system, the sub-system and related technical skills would be identified such as radar transmitter and receiver, driving mechanism, power generation, launcher, weapon, vehicle. and communication and the associated processes required for the electronic and mechanical maintenance (including preventative, field, and shop activities). Then for each of the technical areas the knowledge and ability for each operation would be identified along with the normal growth of the specialist through the system.

r. The models from each approach would be expected to have a high degree of commonality. Much of the information required probably exists in previously performed task analyses. In either case, it should be possible to use the model to identify new organizations of the delivery processes from formal school based training through proficiency maintenance that would reduce costs and improve readiness.

s. A simplifying key lies in job performance aids. Effective performance of the specialist, assisted by his JPAs, is central to reduced costs and increased readiness, and therefore the general goal of technical training. Since 20 percent of the specialist's time is spent in training, optimizing the development and effective use of JPAs for 80 percent of the specialist's career time, and backing through the information delivery chain to define the role of the other components has minimum risk of sub-optimization.

t. Computer based systems such as CTS have the characteristics necessary to provide the management for and direct control over some of the delivery of information in all of the above components in an individualized mode.

u. Thus as information base (curriculum) and associated management system might be designed for a whole technology or specialty with the parameter for individualization to cover not only the difference between specialists, but also their assignments, and the different modes of use (from schooling through OJT and proficiency maintenance to JPA). We probably know enough today to organize such a data base and superimpose onto it different pointing structure and branching mechanisms to provide a system of such scope. As our understanding of artificial intelligence grows we should be able to find even more efficient ways of generating the pointing structure and branching algorithms to cover new weapons systems and devices introduced into the arsenal and its related logistics support. In some specialties individualization discriminating between the needs of the active force and the reserve force might be accommodated. In other specialties where there is sufficient information in common across the Services, a single system with service specific individualization parameters might be considered.

Biographical Sketch

Ruann Ernst Pengov

PERSONAL DATA

Birthdate: September 24, 1946
Birthplace: Beckley, West Virginia

EDUCATION

The Ohio State University, Columbus, Ohio (1964-1968)
B. S. summa cum laude, in Mathematics Education and Computer Science

The Ohio State University, Columbus, Ohio (1968-1969)
M. S. in Mathematics Education and Computer Science

The Ohio State University, Columbus, Ohio (1973-)
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PROFESSIONAL EXPERIENCE

1967-1969	Teaching Assistant, Dept. of Computer and Information Science, The Ohio State University
1967	Scientific Programmer for TRW Systems, Inc., Redondo Beach, California
1968-1969	Research Assistant and Computer Consultant, College of Education, The Ohio State University
1969-1972	CAI Systems Programmer and Analyst, Division of Computing Services, College of Medicine, The Ohio State Univ.
1972-present	Director, Division of Computing Services for Medical Education and Research, The Ohio State Univ., College of Medicine
1972-present	Associate Project Director, Data Communications Services Contract, National Library of Medicine
1973-present	Practicum Coordinator for Graduate Training Program in Biomedical Computing and Information Processing
1973-present	Adjunct Instructor, Medical Communications Division, School of Allied Medical Professions, The Ohio State Univ., College of Medicine

FINAL REPORT

on

Development of Medium and Long Range Plans For Improving United States Army Training

Prepared by

Ruann E. Pengov
The Ohio State University
College of Medicine

February, 1975

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Introduction

a. Based upon the experience of an on-site visit to Fort Gordon, Georgia, the reading of Project ABACUS reports and manuals and conversations with Army officers and enlisted men, this paper will:

(1) Offer comments and suggestions for the current Project ABACUS. Comments on the current Project ABACUS are offered as alterations to an existing "flight plan". This author feels that several alterations in the current Project ABACUS environment must be made for effective extrapolation of project findings to Army-wide Computerized Training Systems (CTS).

(2) Make recommendations for the design and implementation of future computerized training systems in the Army. Recommendations for the design and implementation of future computerized training systems are based upon the observations and experiences of this writer; however, findings from the current ABACUS Project must lend the refinement necessary for fruitful implementation.

b. In reality, recommendations for the current project and for the future project become inseparable.

Suggestions for the Current ABACUS Project

a. The existing preliminary evaluation plan dated January 19, 1974, should be updated and redistributed as soon as possible. Careful monitoring of its implementation should begin immediately thereafter.

(1) Given the change in location for the test site from Ft. Monmouth, New Jersey, to Ft. Gordon, Georgia, and given the change in amount of CMI vs CAI materials used in the project, the evaluation plan is in much need of adjustment.

(2) For example, the evaluation plan dated January 19, 1974, makes careful distinction between:

(a) CAI. In this mode, the lesson material is stored on line within the computer system and the computer serves as the instructional medium.

(b) CMI. In this mode, the computer provides lesson assignments, schedules equipment and instructional media, scores tests and provides remedial work and monitors student progress. All lesson material is presented via off-line media.

(c) CDI. This mode may be considered as a combination of CAI and CMI with part of the lesson material stored on line and part off line. The computer is one of several instructional media used within the lesson.[1]

(3) These definitions appear useful and helpful; however, if the delineations are not maintained in course development and project implementation, the evaluation loses a valuable facet. Project and local staff at Ft. Gordon must be aware of and consciously control the amount and location of CAI, CMI and CDI materials present in the current project. Without such control, extrapolation of the ABACUS Instructional Design Model to future courses and cost effectiveness studies for such extrapolation will be difficult. The cost of building an airplane from various prototypes depends directly on the component characteristics within the prototypes. Without detailed specifications for the engines used, for example, intelligent choice of which to use in future airplanes (and for which purpose) would be impossible.

(4) Discussions at Ft. Gordon in December, 1974, indicated that conscious distinction among the three types of use of the computer in the instructional process is not present in the minds of the instructional developers, course instructors or project staff. This observation alone seems to dictate the need for an on-site evaluator to operationalize evaluation implementation at Ft. Gordon and to effect coordination with the central ABACUS staff.

b. An alternative view of the teaching/learning process should be considered.

(1) In actuality it is often very hard to predetermine where CAI, CMI or CDI will be used. The application and the teaching approach may help determine which type of computer assisted learning is best, but generally, a combination of types is the most effective teaching method. Given the difficulty in matching applications with type of computer involvement, might it not be more fruitful to define components of the teaching/learning process and then determine "if" and "how" the computer could be useful? For example, the teaching of algebraic concepts might be broken down into the following components:

(a) initial presentation of material

(b) drill and practice of the materials presented

(c) evaluation of student knowledge of the material, and

(d) reteaching of the materials (if necessary).

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[1]A PRELIMINARY INSTRUCTIONAL MODEL FOR A COMPUTERIZED TRAINING SYSTEM, Interim Report, July, 1973, page 5

(2) In this example, initial presentation of materials might be less effectively offered by the computer than by a teacher, a text or audiovisual mechanism. Drill and practice is most probably best adapted to CAI. Combination of evaluation and reteaching components could be done by the computer in a CAI or CDI mode while the overall progress of a student through the various modules in an algebraic course and his ultimate testing could be a CMI function. Thus, the type and scope of computer involvement (if any) is determined by the needs of the teaching/learning process rather than having the computer involvement superimposed on the teaching/learning process.

c. A student flow model should be considered.

(1) Development of a model of the student flow through the teaching/learning process described above might be helpful. This model could be applied to the teaching/learning process at each learning unit level (task, subtask, etc.). An example of such a flow for the smallest unit of learning, designated as a task, subelement,[2] is shown in Figure 1. This flow differs from the general course structure flow and from the skill, practice, posttest, task element problem and lesson test strategies (as described in the Preliminary Instructional Model)[2] in that it depicts movement through material from the student perspective rather than from the course structure or instructional design perspective.

(2) Figure 1 is taken from the Ohio State University College of Medicine Independent Study Program.[3,4] This model would need to be altered to incorporate the skill and performance testing of the three ABACUS training test courses. Still the concept is generally valid in that:

(a) The student reviews written objectives. These objectives are developed by the faculty teaching the course and are given to the student. Thus, expected performance and knowledge levels are clearly stated for both the student and the instructor.

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[2]A PRELIMINARY INSTRUCTIONAL MODEL FOR A COMPUTERIZED TRAINING SYSTEM, Interim Report, July, 1973, page 3.

[3]Griesen, James V., "Computer Assisted Idependent Study", Journal of Clinical Computing, Vol. 2, No. 4, pp. 68-76, 1973.

[4]INDIVIDUALIZING THE STUDY OF MEDICINE, various authors of The Ohio State University College of Medicine Independent Study Program, published by Educational Products, Inc., 5005 W. 110th St., Oak Lawn, Illinois 60453, available January, 1975, $24.00.

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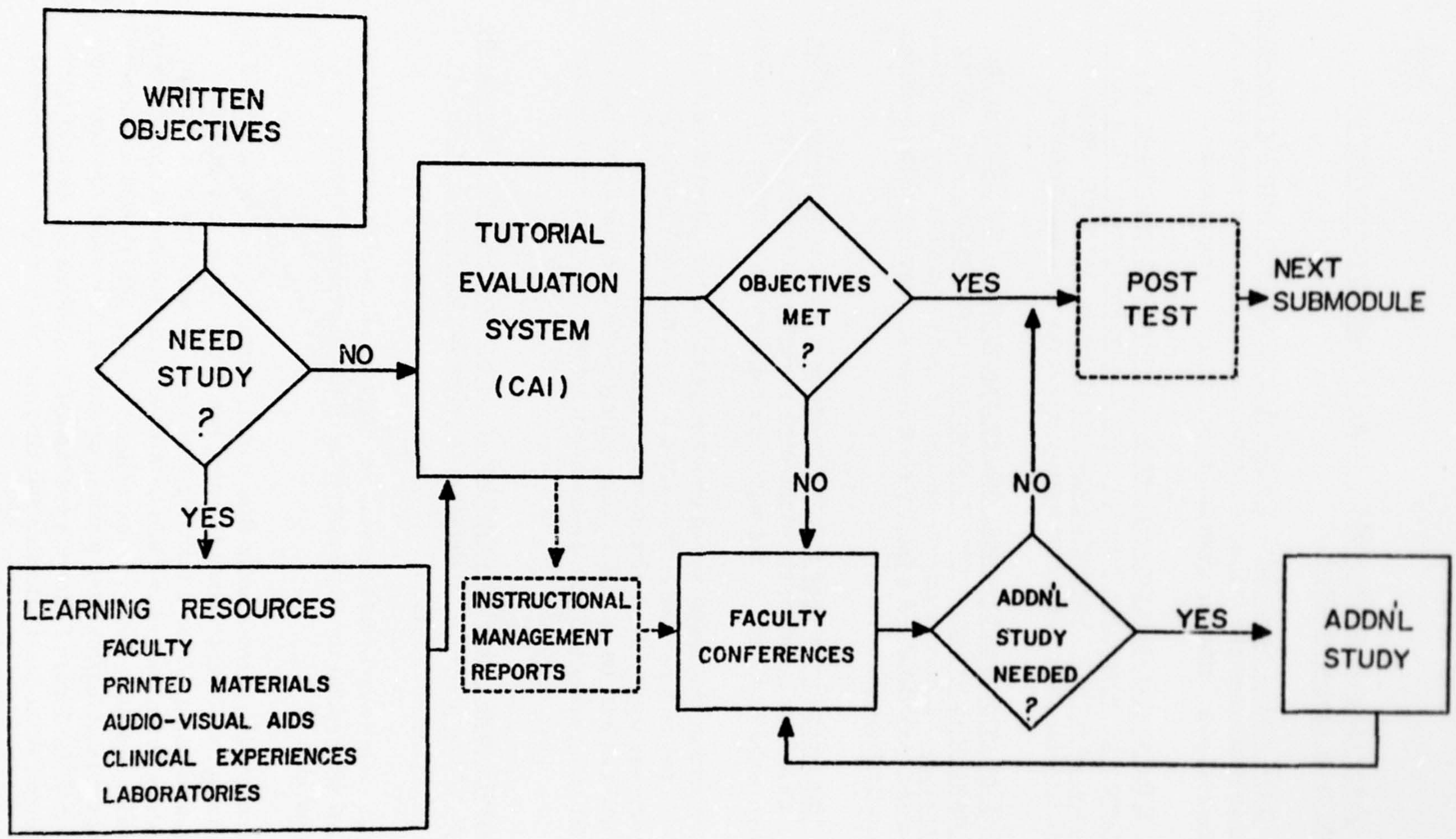


Figure 1. Sample student flow model.

(b) Determination of the need for study is made by the student (if mature enough) or by pretest criteria.

(c) If the student needs further study then a variety of learning resources are used. These resources are delineated by faculty and include printed material, models, audiovisual aids, clinical experiences and CAI learning modules.

(d) If the student does not need study as determined by pretests or by his own assessment he moves to a Tutorial (self) Evaluation System (TES) where the evaluation and reteaching components are combined via CAI/CMI. Students proceed to use the tutorial (self) evaluation system whenever they feel "ready".

(e) If the objectives have been met as determined by the TES then the students may move on to written posttests, laboratory experiences, skill testing or the next unit of study. If certain objectives are not met the student may be directed to additional study, scheduled for a faculty conference or recycled to the learning resources (in a CMI mode).

(f) The computer is used in a CMI mode as a monitoring device within the TES flow. Computer management of the entire teaching/learning process is not part of the model in Figure 1, although such a dimension is certainly possible.

(3) To reiterate, the model shown above emphasizes the independent study concept from a "student flow" rather than from a "systems flow" perspective. Within this model the instructional designers determine where and in what dosages CAI, CMI or DCI can best be utilized. This utilization is determined by the content of material being presented and the instructional strategy best suited to that content.

d. "Miniexperiments" should be inserted in the existing project. This can be accomplished without changing (a) the time schedule for the project or (b) the primary thrust of the evaluation.

(1) These miniexperiments provide an effective mechanism for answering questions which are crucial for implementation of future training systems in a cost effective fashion.

(2) For example, in the student flow model, certain task elements could be presented utilizing non-computerized learning resources; other task elements could be presented using CAI as a learning resource. In one version a tutorial evaluation system on the computer could be utilized while another could utilize a written evaluation system. Such miniexperiments might help cordon off those components of the teaching/learning process or student flow which are best met by CAI, CMI or CDI. Figure 2 offers a conceptual framework for several miniexperiments aimed at the most effective and efficient match of type of computer

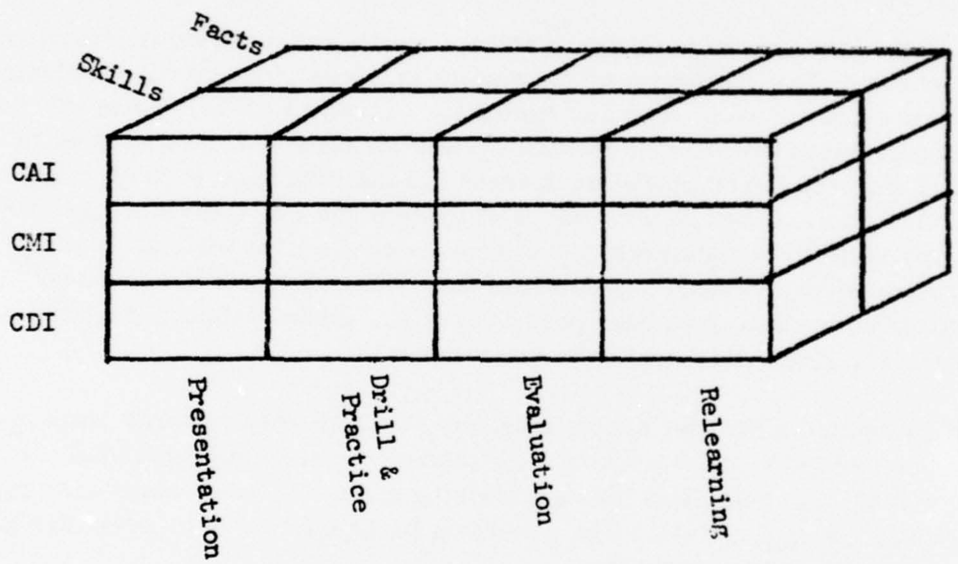


Figure 2. Conceptual framework for miniexperiments.

involvement with components of the teaching/learning process with type of learning. Cost accounting and manpower studies concerning development and support of each of the options is crucial.

(3) Another variation for a miniexperiment might be to allow some students to enter the system based upon pretests placement while others enter based upon their own self assessment. Such a study of student ability to accurately self assess needed areas of study could prove fruitful.

(4) Variations of the CAI support team structure (see pages 101, 103) would provide the setting for additional informative miniexperiments.

e. A mechanism must be devised for "shipping a man out" at the point his training is complete.

(1) If the incentive of early completion via self-paced individualized study is removed or negated by placement of the student in a less pleasant duty assignment until the next class rotation, then any evaluation of project effectiveness will be totally muted. Some incentive or reward system for early completion must be instituted if any cost effectiveness or decrease in learning time is to be realized in project ABACUS. Given an accurate CMI system and well-developed predictor equations for student performance, the student in conjunction with his advisor, must be able to plan a projected graduation date with considerable accuracy.[5] Early graduation must be rewarded positively (i.e., given advanced training) not negatively (i.e., given additional duty assignments).

(2) Viewed on a broader scope the Army will also reap rewards from providing proper exit paths from training. By placing the student immediately on the job or by moving him quickly to his next training area, the Army saves training time and potentially training dollars. The problems in the current exit procedure guarantee no possibility of time savings.

Recommendations for Design and Implementation of Future Computerized Training Systems

To this writer, two areas appear as prime candidates for consideration in design of computerized Army training systems for the future. The first involves the personnel support for production, maintenance and updating of computerized courseware. Inherent in this area are the problems of career path and incentive for members of the course development team. The second involves mechanisms for

[5] Technical Documentation for the Computer Assisted Instruction Reporting System (CAIRS), The Ohio State University College of Medicine, Division of Computing Services (1973)

utilization of computerized training systems in the continuing education of Army personnel. Both recommendations address components of the total training life cycle which appear vulnerable to cost reduction with a better systems arrangement.

The Course Development Team

a. The Course Development Team operating currently in Project ABACUS, (individuals designing and developing CAI, CMI or CDI materials) is composed of:

(1) An instructor from one of the three test courses (MOS 31E20, Field Radio Repair; MOS 31J20, Teletypewriter Equipment Repair; and MOS 35L20, Avionics Communications Systems Repair) who has been trained in the CLASS I authoring language, the instructional model, teaching strategies and lesson development techniques and procedures. This instructor is also the content expert.

(2) A course leader coordinates the design and integration of CTS in the overall course structure.

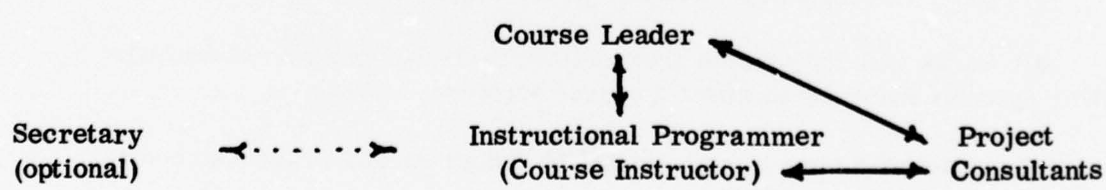
(3) In some situations a secretary enters the CLASS I commands at the computer terminal.

(4) Consultants from the central ABACUS staff. These individuals have expertise in instructional strategy design, instructional technology and CLASS I coding.

b. Figure 3 offers a diagram of the interaction of the members of the current course development team.

FIGURE 3

Current Project ABACUS
Course Development Team



c. Using the preliminary instructional model for CTS, the instructor operates as instructional programmer (I. P.) developing new CAI, CMI or CDI materials. Theoretically the I. P. is to follow the instructional model and use his knowledge of content and of instructional design combined with input from the Course Leader and Project Consultant to determine which instructional medium to use for each teaching/learning task. The expertise required in this process is probably more than the I. P. is prepared to exercise alone and yet in current project implementation the I. P. is given such responsibility. This consultant's conclusion is that, by default, no analysis of appropriate "medium-message" mix is being performed and that the Course Development Team approach in the current project must be altered to afford the teaching/learning perspective delineated on page 103.

d. A second significant draw back exists in Figure 3 in that the I. P. currently is an instructor in a course area who has been retrained as described above to become a developer of CAI, CMI and CDI materials. As such he must learn instructional design and computer programming. Extrapolated to a broader Army scale, the net effect of this manpower retraining is staggering. Not only are trained teachers being unnecessarily retrained as instructional developers and programmers, but each new I. P. begins at level 1 proficiency in instructional design and in instructional programming. With each new area converted to the CTS training approach, instructors in that area would experience the growing and learning problems faced by instructors (instructional programmers) in other areas--in short, the lesson learned at each implementation site would not be fed forward effectively.

e. An alternative course development team structure is shown in Figure 4. This model depicts the major actors as the author and the instructional programmer (I. P.). Hence, the content expertise resides in the author (or instructor) while the I. P. serves as the primary interface between the author and the other members of the team. The author remains the content specialist, the teacher in the classroom environment, the advisor to the student and the overseer of the computer managed instruction. The instructional programmer:

(1) consults with the author regarding the objectives, strategy and design of materials,

(2) codes and inputs the material in the CLASS I language,

(3) works with the system programmer to design new course facilities and/or systems functions to effect a course strategy,

(4) works with the systems analyst to design student progress reports, course item analyses as required,

(5) arranges for students to review new CAI courses,

(6) arranges for additional content reviewers as required,

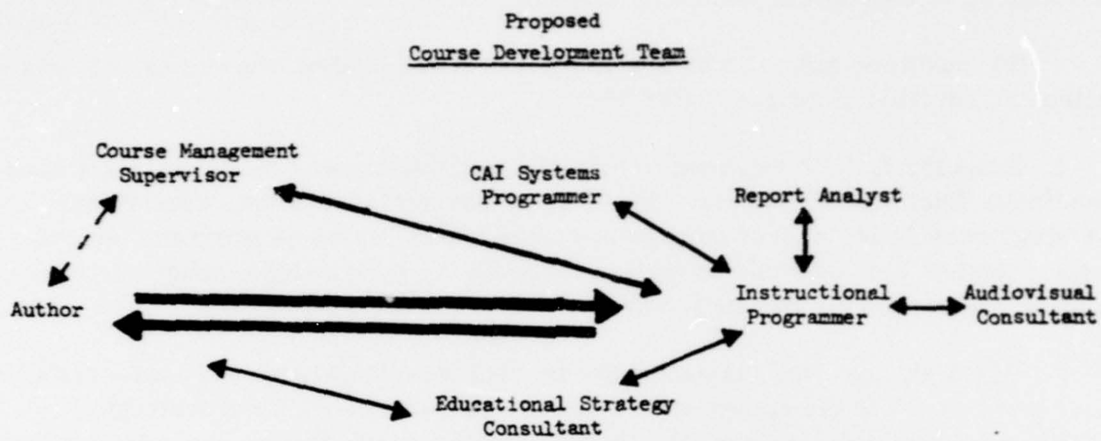


Figure 4. Proposed course development team.

(7) consults with the author and the audiovisual consultant on the use of audiovisuals in conjunction with the CAI courses,

(8) remains the on-going caretaker, reviewer, revisor and troubleshooter for the course once it is made available for student usage (this includes continual monitoring of student response reports) and

(9) monitors and helps interpret statistics and student reports used in evaluation and revision of course materials.

f. Since the I. P. is expected to be a "jack-of-all-trades" he or she must have available "back-up" resources. Thus, an audiovisual consultant, educational strategy consultant, course management supervisor, systems programmer and report analyst are available as needed to assist the instructional programmer and/or author in their respective areas.

g. The I. P. assumes responsibility for technical knowledge and system interface and thus frees the author-instructor to work with content and strategy.* Within a course, the strategy, the lessons and the points for the computer assistance are defined by the author/instructor in consultation with the I. P., the course supervisor and the educational strategy consultant. The instructional programmer along with his consulting educational strategist and author/instructor becomes an artist who helps determine which components of the teaching/learning process should involve CAI, CMI, CDI or other media. The I. P. helps determine when to combine testing and evaluation (see student flow page 97), when to suggest alternative learning resources, and how to efficiently and effectively implement the educational strategy for a given training area or objective.**

h. The educational strategy consultant and the systems support staff for the instructional programmer (potentially from a central Army group such as the current ABACUS central staff) could be called upon to train new instructional programmers, to assist them in implementation at each CTS training area and to provide continuing consultation as needed. Once implementation is completed some instructional programmers would be left on site at the training center to effect

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*This concept does not negate the need for more refined authoring languages in this model. Such enhancements would only make the I. P.'s more productive.

**At this point it should be noted that the division of responsibility among members of the development team, as delineated above is not rigid. In fact, care must be taken to avoid overcompartmentalization of tasks, since the team effort is crucial.

continuing revisions, troubleshooting and upgrade of the CTS system materials. This continuing maintenance would be done in concert with the course supervisor and instructors in each training area. As a trained technical specialist the instructional programmer along with the support staff shown in the above model could move rapidly to spearhead implementation of the CTS concept in each Army training area.

i. The above model has been used for some time at The Ohio State University College of Medicine. Currently, instructional programmers operating in the environment of the model produce approximately three to five new hours of CAI instructional materials per month. This is in addition to responsibilities for revision, maintenance, and troubleshooting for some 200 operational CAI units. Figure 5 offers average course development times by type of CAI and assumes an inexperienced author and an experienced instructional programmer. The "types of CAI" are defined below:

(1) Tutorial Evaluation: Simple linear programming of questions with appropriate feedback to individual responses; hints or coaching sequences may be included.

(2) Tutorial Evaluation with Options: Simple programming of instructional questions which permit the learner a choice of sections, questions or informational material.

(3) Tutorial Evaluation with Question Branching: Programming of questions and sub-questions which further individualize the material according to prerequisites, objective achievement and non-achievement; assumes standard student data base retained.

(4) Diagnostic Instruction: Extensive individualized instructional programming within questions or groups of questions which permits the learner and/or the system to identify learning problems and have the opportunity for drill and practice or prerequisite "make-up"; assumes an expanded student data base with tagged questions and branching accordingly; branching increases the learner's control of the activity.

(5) Individualized Tracking: Programming, according to response data which allows question branching with appropriate feedback specific to a learner's background and prerequisite and objective achievement; the tracking concept may be utilized to allow a learner to progress through the material according to the response and thus approach a "quasi" simulation learning activity.

j. As can be seen, the author time involved for development of various types of CAI utilization would be significantly greater if instructional programming

CAI COURSE DEVELOPMENT

TYPE OF CAI	INITIAL AUTHOR EFFECT	INSTRUCTIONAL AUTHOR INTERACTION	PROGRAMMER CODING & DEBUGGING	AUTHOR REVIEW & REVISION	ADDITIONAL REVIEW	COURSE DOCUMENT.	TOTAL DEVELOP. TIME
LINEAR Tutorial Evaluation	25	5	10	10	5	5	50
LINEAR with OPTIONS	30	5	10	15	5	5	70
LINEAR with QUESTION BRANCHING	40	10	30	20	5	10	115
INSTRUCTIONAL DIAGNOSTIC	80	30	50	40	10	15	215
INDIVIDUALIZED TRACKING	100	50	100	50	40	20	330

AVERAGE DEVELOPMENT TIMES IN HOURS FOR ONE HOUR OF TERMINAL INTERACTION

Figure 5. CAI course development.

interface were not provided. The extent of the time savings is underestimated in Figure 5, since instructional programmer time is based upon the past expertise and cumulative experience of a pool of I. P.'s.

k. The significance of the I. P. for review maintenance and revision of existing courseware must not be overlooked. Not only is this individual invaluable in making minor changes, adjustments and refinements in content, but this person will automatically perform all necessary system upgrades, conversions, and alterations in the courseware which should be transparent to the user and the author. As an example of the time consumed in one such maintenance function, Figure 6 shows the average time spent by an instructional programmer and management supervisor or author in conversion of course units from a 100 character lines to 70 character lines. The figures are even more impressive when one notes that all courses first passed through a master convertor which performed initial translations. I. P. time was spent in refinement and in realignment of changes which could not be properly managed by the program. The management supervisor (author review) time was spent for changes in which the line length affected the educational presentation and validity of materials. Given a) the total man hours required for upgrade of one hour of interactive CAI (25.8 hours) and b) two hundred and eighteen course units averaging two hours each, there were four hundred and twenty six interactive course hours of OSU materials to upgrade. Thus 11,249 man hours or 281 man weeks, or over 4 man years were spent in the conversion. Extrapolation of this to all Army training areas gives some appreciation for the amount of maintenance and revision time required for computerized teaching materials.

l. And finally, three very important side effects of the instructional programmer and support team concept as described above must be considered:

(1) Given this model, educational strategy and application of CAI materials always holds first priority over fancy hardware and computer systems. This is due to the fact that the computer support individuals (systems programmers and report analyst) exist to support the instructional programmer and author rather than to direct them. The model operates to meet the educational needs rather than to direct them.

(2) Definition of what is to be developed comes from outside the computer support team and eliminates the tendency of the computer support group to breed a life of its own.

(3) Each new Army training area or course development effort utilizes the staff and expertise in the central support unit. Small support "fiefdoms" each "recreating the wheel" of CAI, CDI or CMI are not allowed to form. Each effort

100 TO 70-30 CHARACTER LINE CONVERSION

	TOTAL	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.
NUMBER OF COURSE UNITS CONVERTED	109	19	20	10	14	19	3	5	19

AVERAGE INSTRUCTIONAL PROGRAMMER TIME: 20.8 HRS.

AVERAGE MANAGEMENT SUPERVISOR TIME: 5.0 HRS.

Figure 6. Character line conversion.

builds upon the knowledge and expertise of past efforts; lessons learned by support staff or authors on one project or in one training arena can be applied immediately to others.

m. A word of caution must be rendered in any model which suggests separation of computer hardware and software support staff from the instructional course development staff. In such an environment, artificial "walls" can hinder the appropriate communications of system needs, alterations and evolvement. Care must be taken to insure that although the instructional programmer and non-technical course development staff function in one arena and the computer systems design, software and hardware support individuals function in another arena, the two are constantly aware of concerns, needs and restraints of the other. Clearly, training needs ought to dictate the computer hardware and software support needs, but at the same time the course development team must be aware of the constraints under which the computer system support group functions.

n. The above model does not necessarily advocate one centralized hardware and software computer support system. The general model is one of separation, of powers of computer support individuals from instructional design support individuals, regardless of whether there is one national computer network, regional networks, or individual computer systems at each Army training center.

o. A potential drawback in Army use of the above model is that no long term incentive, Military Occupational Specialty (MOS) or career path exists currently for members of the course development team. Civilians could be used where the criterion of "world wide military use" does not dictate a military career area. The civilian option would allow for higher level entry grades and could be particularly applicable to the educational strategy consultant for example.

p. An appropriate career pattern and reward track for instructional programmers might include advancement to warrant officer where potentially the position of chief warrant officer for support of training systems could evolve at each Army training center. This warrant officer could work as a team leader in the course development process and could supervise implementation and operation of the CTS support system at the training center. Alternatively an MOS of instructional programmer might be justifiable if an Army-wide implementation of CTS (pages 110-112) became a reality. A senior instructional programmer (e.g., Senior Sergeant could a) supervise groups of I. P. 's b) offer consultation regarding "if" and "how" to incorporate various instructional technologies into Army training and c) help integrate CAI, CMI, and CDI into the other instructional technology areas (i.e., (AVTV) in the Army).

q. For the Army officer involved in the above model, a specialty program similar to that of "Audiovisual Instructional Technology" in the Officer Personnel

Management System might be appropriate. Optionally, for these individuals who have existing professional expertise in instructional strategy and modeling, might not a career path similar to that of the Army M. D. be a feasible solution?

r. In summary, the problems of appropriate mix of Army and civilian personnel and stabilization and career path for Army personnel must be addressed.

Extrapolation of the CTS Concept

a. The second long-term recommendation observed as relevant by this consultant relates to extrapolation of the CTS concept beyond the point of implementation at each Army training center. The paragraphs which follow are admittedly long-term in prospectus; still the potential which they address should not be overlooked. First, assume as given, the implementation of computerized training systems to allow for truly individualized time-independent movement through all major Army training programs. Furthermore, assume that the computer network supporting the training system is national in scope. Under these conditions each Army installation could become a training center for all content areas in the CTS national system. Army personnel could complete necessary training for a given area without physically changing installations. Major training centers would exist only where learning required equipment, tutors or other resources not normally found or cost-effectively placed on any Army installation. Some courses (i.e., Army procedures and forms design) could be centrally designed and administered but actually taught via CTS at each installation. The audiovisuals, workbooks, etc. could be made available at each installation just as tutors and student advisors could be made available to answer questions and to verify student proficiency. Such advisors could hold regular jobs on the installation and consult or tutors only part time. Other courses (i.e., helicopter repair) would most likely be regionally based since equipment and competent instructors would not be available at every Army installation.

b. Technically, however, the system with CMI reporting, computer assisted instruction, computer directed instruction and transportable learning components (i.e., tapes, audiovisuals) could be utilized in a learning lab environment at each training installation. Students could then be sent to the nearest installation to proceed with training in a specialty area (covering as many content areas as possible at one given location). Such a decentralized training system would address two very important problems in the current system.

(1) The cost and personal trauma of transfer of individuals from location to location.

(2) The "red tape" timing problems in movement of individuals from one installation to another upon completion of a segment of training.

c. The author must note that only the most careful of studies will determine whether the system proposed above will truly address the problems in a cost effective manner.

d. The situation proposed above is not totally different from ideas from extrapolation of the basic sciences portion of M. D. training to remote areas where no medical school exists. In the WAMI Project[6] basic sciences study is being offered in a four state area (Washington, Alaska, Montana and Idaho) from one central medical school base at the University of Washington. Knowledgeable medical course advisors and tutors are available at learning centers in each of the states while the instructional materials are developed, designed, maintained and distributed from the central site at the University of Washington. Upon completion of basic science training, the students move to the University of Washington for the clinical experience where work with patients is required.

e. Potentially such a centralized computerized training system could piggy-back on an existing national network.[7, 8] Experience has shown that the system load for transfer of educational materials is minor in a large data transmission network (i.e., 5 to 7 characters per second). This determination would, however, have to be based upon accurate figures involving the number of students to be trained, the type of CAI and the amount of materials and training offered via CAI and other modes.

f. Potentially, the most exciting outcome of the above extrapolation of the computerized training system concept would be that of providing an on-going data base for continuing education. By having materials continually available to every base on the network, the operational individual (i.e., the radio repairman) need

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[6]A proposal to the Veterans Administration for experimentation in Bio-Medical Communications using the ATS-F communications satellite and ten Veterans Administration hospitals in the Appalachian region submitted jointly by: The Appalachian Regional Commission and the Foundation for Applied Communications Technology.

[7]Lewis, Jinnet Fowles and Wooster, Harold, "Description and Utilization of the Lister Hill Center CAI Experimental Network" (unpublished paper) presented at the Association for the Development of Computer Based Instructional Systems, August, 1973.

[8]Combs, Bill, "TYMNET: A Distributed Network", Datamation, July, 1973

simply come to the CTS system periodically for testing, recertification or restudy. Centralized files on performance and proficiency could be easily maintained for consideration in promotions, etc. Furthermore, increased student awareness of his own continuing education needs might be worthy of exploration. Individuals could be given the opportunity to review materials at any time and/or required periodically to go through the recertification process without having to leave their operational installation site.

g. Similar experience in the medical environment has been achieved through the efforts of the Computer Assisted Instruction Regional Education Network within the state of Ohio.[9] This network of community hospitals utilizes materials developed for primary training of nurses, physicians, and allied health personnel. Continuing education credit for the CAI exercises has been rendered by the American Medical Association, The American Dietetics Association and other such organizations. Thus, the physician or other health professional in a small town in Ohio can draw upon the expertise and materials from major university for self-learning and study to fulfill requirements for recertification. Currently, a similar concept for recertification of internists is being explored by the American Board of Internal Medicine.[10] Recertification will be based upon performance in simulated case studies available to the internist in his local community via a computer terminal.

Summary

a. In summary, the project thrust and evaluation perspective should be altered to view the type and scope of computer involvement as determined by the needs and characteristics of the teaching/learning process, rather than by a predetermined plan which superimposes computing indiscriminately on the teaching/learning process (pages 95, 96) and student exit from the teaching/learning process (page 100) must be addressed.

b. Implementation of the CTS concept beyond Project ABACUS further dictates review and restructuring of the course development team with particular attention given to career path, incentive and stability for Army personnel involved. Extrapolation of the CTS concept to Army-wide training and continuing education affords potentially the most exciting cost effective and productive use of computer based learning in the Army environment.

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[9] Pengov, Ruann, "The Computer as an Additional Aid in Medical Education", Proceedings of the Tenth Annual Council Meetings and Conference of EDUCOM, 1974.

[10] Harless, William G., Drennon, Gary G., Marxer, John J., Root, Judith A., Wilson, Linda and Miller, George, "CASE--A Natural Language Computer Model" Computing in Biological Medicine, Vol 3, pp. 227-246, printed in Great Britain.

Biographical Sketch

LTC Alan B. Salisbury

LTC Alan B. Salisbury is currently assigned as the Director of the Center for Tactical Computer Sciences (CENTACS), Communications/ADP Laboratory, US Army Electronics Command. He holds a BS from the US Military Academy and MS(EE) and Ph. D. (EE) degrees from Stanford University. LTC Salisbury's graduate work was in the area of digital systems engineering with a full minor in Computer Science. Particular areas of expertise are in the fields of computer architecture, microprogramming and emulation.

Previous military assignments include Office of the Project Manager for Army Tactical Data Systems (ARTADS); Technical Advisor to the Director of Management Information Systems, Office of the Chief of Staff, HQDA; and Chief, Communications Division, Operations Directorate, HQ 1st Signal Brigade, Republic of Vietnam (RVN) with responsibilities including the installation and operation of the AUTODIN system within RVN.

LTC Salisbury has authored numerous technical papers, a book to be published in 1975, and has been on the faculties of the US Military Academy Virginia State College, American University, New York Institute of Technology, and Fairleigh Dickinson University. He is a member of the IEEE Computer Society, the Association for Computing Machinery (ACM), the Society of the Sigma Xi and several other technical and professional organizations.

The Impact of Technological Developments on Army Training Systems (1975-1985)

by

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Background and Statement of the Problem

Technological developments within the computer industry are advancing at a rapid pace, particularly in the hardware area. Even in a period of general economic recession and inflation, these developments have been (and can be expected to continue to be) significant enough to expand existing markets and open new market areas with a downward trend in prices. This brief paper will highlight some of these developments which should have an impact on Army training systems of the future and make some general recommendations on areas which should be considered in future system designs.

Discussion

a. The most significant development in the electronics/computer industries of this decade has undoubtedly been the microprocessor, or CPU on a chip. It can be safely said that this development will revolutionize the electronics industry and have a major impact on the computer industry. Just as the introduction of minicomputers expanded the computer industry and market by an order of magnitude, the microprocessor can be expected to have a similar order of magnitude impact in the near future and several orders of magnitude additional impact in the long term. It is probably also safe to say that whereas computer technology and applications have been applied by only a small portion of electrical/electronic engineers in the past, they will be common and essential tools of the vast majority of these engineers in the future. Few areas now employing electromechanical or electronic control systems of any degree of complexity will not fall into the domain of microprocessors in the years ahead.

b. The vast markets that can thus be envisioned for microprocessors give rise to anticipated low costs for these devices. Already it is possible to buy complete microcomputer systems (including CPU chip, minimal memory and I/0 logic) for as little as $29.95 in quantity (INTEL 4040). The limiting cost factors are generally pins, interconnectors, packaging, etc., rather than the devices themselves. With chip component/device densities doubling almost every two years, we can look for continued improvements in these areas.

c. Another related technology development area is solid state (semiconductor) memories. Here too benefits are being realized from the increasing density trend in integrated circuits. The day is not too far away when semiconductor memories will edge out magnetic cores for main memories on an economic basis and efforts now underway on solid state BORAMS (Block Oriented Random Access Memories) foresee them replacing many disc storage systems as well. Within the time frame considered for this paper it is possible to project solid state (semiconductor) memories being readily available up to, perhaps, the megabyte level. Truly mass memories will probably continue to be dominated by discs, with solid state systems being employed in a limited number of special systems. Some speed improvements can also be foreseen.

d. Display technology can be expected to make significant advances. In particular plasma, LED (Light Emitting Diodes), and thin film technologies can be expected to yield improved performance characteristics (density, color, and gray scale) at affordable prices. Another area which should move into the functionally useful and affordable category is voice input/output. Discrete (word at a time, limited vocabulary) speech recognition systems are in use today in limited application areas and work is continuing at a high level in continuous speech recognition. Voice synthesis units are also in use today as output devices and are continually improving.

e. Given these technological trends what are the implications for the Army and its future design of training systems?

(1) Overall system architectures will probably shift somewhat toward the decentralized/distributed concept and away from the large centralized system. Concurrent reductions in communications costs will continue to make centralized systems viable, particularly where resource sharing with nontraining systems is desirable. Nevertheless, microprocessor (microcomputer) developments and lower cost memories will have a significant impact on terminal design and cost. Concepts now employed in the ABACUS distributed miniapproach can be further exploited through "more intelligent" terminals reducing requirements now placed on the display controllers and the system controller. Portions of the data base system can be considered for decentralization as well. It should be possible to proceed in the direction of modular systems with varying numbers of terminals; the system could readily accommodate an expanded number of terminals since the new terminals would bring with them most of the additional processing power required. At the low end, it should be possible to achieve virtually stand-alone systems with as few as one or two terminals employing tape cassettes for course loading and administrative files. This would be particularly attractice for remote training requirements, such as Army Reserves and National Guard, permitting them to utilize the same courseware developed for active Army use.

(2) Terminal design will be impacted in several ways. Display technology will probably facilitate improved graphical capabilities and student interaction. These should be planned for in terms of course development. The particular technology that proves to be most suitable in the long run is not a major consideration at this time since their capabilties are similar. It should be noted that PM, ARTADS currently has an advanced development project under way for the design and fabrication of an Interactive Computer Presentation Panel (ICPP), intended to provide an interactive display device to superimpose graphics on standard Army maps. The technology being developed (hardware and software) will have potential applications in training, and the ICPP itself may be of use in team training situations.

(3) Microprocessors and inexpensive semiconductor memory can provide more intelligent terminal capabilities as previously discussed. Further, microprocessors can readily be employed as multi-media device controllers to enhance terminal performance.

(4) Associated with CAI/CMI terminals, special purpose devices configured as instrumented (on-line) mockups of selected military equipment can be fabricated employing microprocessors to assist in limited equipment simulation. Such devices would be applicable both to individual and team training situations. The capability to tie such devices into the overall system in an on-line mode would significantly enhance equipment oriented training functions, further reducing requirements for training personnel and improving individual problem diagnosis and subsequent remedial actions.

(5) Audio (speech) input/output has utility in some areas, but should be used sparingly. Audio input from the student may be of use where an effort is being made to completely simulate an operational environment. This is another area where an ongoing effort by PM, ARTADS may be of assistance. A current advanced development project will result in the delivery to the Army of a Discrete Speech Word Recognition System (WRS) aimed at allowing voice input to tactical data systems (e.g., fire mission requests to the Tactical Fire Direction System). This system may be available for limited experimental use in training if an appropriate test situation were devised on a noninterfering basis with ARTADS.

(6) Future Army training systems should make greater use of CAI while retaining CMI functions. Projected terminal economics should make this possible. For the CMI functions, however, a hard copy capability should be added to the terminal. Detailed individualized instructions prepared for a student's off-line usage could then be delivered in a form to facilitate his compliance with those instructions.

(7) Performance of the system in a CMI mode can be further enhanced by the utilization of source data automation to the maximum extent possible. This is to free the instructors/testors/evaluators or other administrative personnel

from having to enter off-line generated data into the system. On-line equipment simulaters are one example of how this can be accomplished. Other special purpose devices/terminals should also be considered where appropriate. Intermediate documentation should be minimal, if not eliminated entirely.

(8) Finally (as an aside), some thoughts on the application of educational technology to complex equipment/system oriented training are offered. One area in which technology can not be expected to lead to significant improvements is lead-time requirements for the development of new hardware and/or software systems. Hence training requirements and implications must be considered from the earliest possible time in the development cycle of any new equipment or system. This will enable early decisions as to the optimum method of accomplishing required training. In some systems (those having significant internal computer facilities, for instance) it may be possible to utilize the system itself (or perhaps with minimal augmentation) for training purposes; others may be best taught via system hardware simulators; still others may require only good software packages. The important thing is that any required development should take place concurrently with the target equipment, consistent with the risks associated with potential changes in that equipment. The design of any Army training system can be effective only if it adequately considers the nature of the training for which it will be utilized when it becomes operational.

Conclusions and Recommendations

a. In summary, future technological developments can be expected to create a number of opportunities for significant improvements in Army training systems. Microprocessors, semiconductor memories and display technology all are candidates for exploitation in future designs.

b. Specific recommendations offered for consideration are the following:

(1) Continue to pursue distributed system architectures. Evolve toward a modular incremental system with intelligent terminals and minimum overhead equipment requirements.

(2) As an objective, the intelligent terminal high performance and should lead toward a minimal capability stand-alone system.

(3) Terminal design should consider the use of high-performance microprocessors and semiconductor memory to provide local processing capabilities, improved graphics and multimedia control functions.

(4) Microprocessor driven equipment mockups and simulators should be considered for improved performance oriented training capabilities, both in individual and team training situations.

(5) Hard copy output and source data automation input capabilities should be considered for improved CMI performance.

(6) PM, CTS should maintain cognizance of PM, ARTADS display (ICPP) and speech recognition (WRS) systems for evaluation of the potential these technologies have for training.

(7) Training requirements for new systems and equipment should be considered from the earliest possible point in their development to allow for possible incorporation of training facilities in those systems and/or development of training packages, simulators etc., concurrently with the target system.

Biographical Sketch

Robert J. Seidel, Ph. D.
Human Resources Research Organization

Dr. Robert J. Seidel is currently the Program Director for the Instructional Technology Group and Senior Staff Scientist with the Human Resources Research Organization. As Program Director, he provides technical supervision for a multidisciplinary staff of scientists. Dr. Seidel's areas of expertise include design of individualized instructional systems, technology transfer, and evaluation of educational processes. During the past fourteen years, Dr. Seidel has had a history of research experience in the area of learning and human problem solving, and he is currently directing an interdisciplinary research and development program in CAI. He is the Principle Investigator of two instructional technology projects supported by the National Science Foundation. One involves implementing computer based learning in a league of secondary schools in the Metropolitan Washington, D. C. area. A group of high school mathematics and science teachers has been trained to introduce computer based educational programs in their schools. Students from the schools are studying how the computer can be used to help solve problems in science, mathematics and in other subjects. Emphasis is also placed on developing computing literacy. The other project deals with a national state-of-the-art survey and conference. The major objectives of the conference are to communicate the possibilities of fourth-generation computer technology to national educatichal planners, to give leaders in educational technology an opportunity to participate in the evaluation of the educational significance of these new developments, and to provide information on fourth generation computer technology that will be understandable to non-hardware experts.

After obtaining his Ph. D. in Experimental Psychology from the University of Pennsylvania in 1957, Dr. Seidel entered the military service. By 1961 he was providing the technical advisory service to the Army on curriculum development in CAI. He then spent a year in research and study at Stanford University's Institute for Mathematical Studies in the Social Sciences.

He has gained editorial experience in service on the editorial board of Instructional Technology, an international journal, and as editorial consultant for Spartan Books. He is a member of the Field Reader Group for the National Center for Educational Research and Development, Office of Education. He is a noted writer in the field of instructional technology and has contributed over 40 papers to the literature--his latest, a book entitled "Learning Alternatives in U. S. Education: Where Student and Computer Meet," (co-authored with Hunter, Kastner and Rubin) has just been published by Educational Technology Publications, Inc., Englewood Cliffs, NJ.

A Proposed Integrated Training System Model (ITSM)

by

Robert J. Seidel, Ph. D.[1]

Human Resources Research Organization

Introduction

a. The following discussion of the proposed ITSM covers four basic facets: (1) a formal management mechanism for continued feed-in and feedback (cybernetic) relationships among research, development and operational implementation of innovations; (2) establishment of a National Center for Instructional Technology to coordinate and accomplish the required R&D for innovative training techniques; (3) continued development of new hardware technology (especially computers) as a means of addressing the manifold problems of training and upgrading requisite training materials; and (4) conceptualizing the ITSM as an evolving system with a template that could aid all military Services.

b. I will first deal with the last item concerning an example of the way such a functional organization might fit into a National Center within the ITSM. Figure 1 illustrates the functions in the following way. TRADOC would submit, through its operational review board, new projects which would be approved and selected for research or development at the National Center. Personnel would be experts in a potential development effort and would be sent on a TDY status to the National Center. Here, if they did not have training in the use of innovative instructional technology, these developers or instructors would be trained in techniques such as programmed instruction, computer based learning developments and whatever other advanced technologies might be available at the Center. Administrators, as shown in Figure 1, might also be sent to the Center for training in the new roles that they would take on given the use of the innovation which would be under development (such as counseling modes available to them in the use of CAI or computer-based simulations, etc.). At the Center proper, there would be a staff nucleus maintained which would be headed by a manager to oversee the various R&D projects. The development side of the Center would concentrate on exactly what is within Figure 1, namely, development of a particular curriculum effort. This would be accomplished through the use of personnel from the field, the experts in the particular subject matter, and the instructional technology experts of the Center staff. As the new project goes through the development cycle, it may well be that potential spin-offs in the form of new research hypotheses would be generated. For example, it might be that the uses of graphics come up as a question for research

[1] "This paper was prepared by the author as an independent consulting effort and in no way represents the opinion or policy of the Human Resources Research Organization."

to answer in a particular class of training. This hypothesis then would be discussed with the research staff at the Center and, if found appropriate a research project would be generated to cover strategies that might be generated to cover strategies that might be employed to deal with the question of graphics. Secondly, should the requirement be for new technology to display such graphics as are indicated in the hypothesis, then the hardware technology staff would be consulted and the project might design hardware as well as instructional strategy research as part of its coordinated effort.

c. Following the project development through to completion, once the new effort is completed within the Center--that is, the subject matter has been thoroughly gone through in terms of behavioral objectives, specifications of media requirements, clearly laid out relationships between prerequisite structure components of the subject matter--it then would become the province of the quality control staff at the Center. They would put the materials together in the proper packaging and through the dissemination capability at the Center would send the packaged innovation (the example shows computer based learning materials (CBLM) simply because this is the most advanced innovation currently being worked on) to the various user sites. At the user sites, whether they be Army Schools or Units--and if we look to the future there will be a greater concentration on Unit instruction--the second component of the dissemination staff, namely the staff at the user site, would help the particular Unit or School prepare the site for efficient and effective utilization of the new subject matter. This would involve technical support of the local staff, as well as training them in the educational or training implementation of the new package to be incorporated into the instruction available at the user site. This would also involve demonstration and sampling of the way in which the innovation works. As Figure 1 indicates, delivery of the material, should it be computer based, might well consider the network possibility from a central source to telephone lines or microwave or other such communication links as might be deemed appropriate to the potential operational users. Moreover, at the site itself, once the dissemination staff working closely with the unit site gets familiarity with the particular innovation, new requirements might be generated. It is important to note that the new requirements are not necessarily going to be simply a function of the experience with a particular innovation, but may well come from experience on the job or at the school. In any event, the dissemination staff at the user site would help in packaging the new requirements and putting them into a form which would be understandable in common language to the Center staff.

d. One more item not covered yet would be the function of pilot testing and revision. As indicated in the dotted lines covering the relationship between the quality control staff and operational sites, the pilot testing would take place once the packaging has been accomplished by the quality control staff at the potential

January 6, 1975

SUBJECT: Consultant Report to CTS

TO: Dr. Joseph S. Ward, Educational Technology
Organizations and Systems Research Lab
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FROM: Dr. Robert J. Seidel

The problems addressed are potential short- and long-term goals in terms of the two sets of considerations--the original intent and design of CTS as compared to the revised intent and design. The original concept of the CTS was that a prototype delivery system would be for CAI tutorial instruction and that the location would be at Ft. Monmouth,New Jersey Signal School. With the change in the location of the system now to be implemented at Ft. Gordon, there have come a host of other changes which necessitate comments before making recommendations. First of all, there have been a significant number of changes in the intention to use the CTS for CMI purposes as opposed to CAI purposes. The staffing has been changed considerably, particularly at the management level at Ft. Gordon.

The questions that arise then relate to whether or not the previously designed delivery system will be appropriate for a different set of purposes and, secondly, whether or not the original schedule can be maintained for final delivery of the CTS prototype. The original version of the system was to have a fair degree of graphics and a tutorial interactive kind of environment in the main for instructional purposes. However, from our review of the current status of the project, a solely interactive graphics CRT capability may not be as appropriate for the CMI environment which is now foreseen. Another question to be reconsidered concerns the possible provision of an automated scheduler for allocation of all instructional resources (other media, reference manuals, etc.). Additionally, a CMI oriented approach involves considering the addition of a second kind of terminal, different staffing requirements for development, etc. The larger question, also relevant from the beginning, of transfer to other schools and other courses, must now be reexamined in the light of the change in implementation to take place at Ft. Gordon.

In like manner, from a configurational viewpoint: Is the current design going to be upward compatible with a viable, new system alternative for follow-on development and implementation (e.g., the hardware configuration, per se, local versus teleprocessed, maxi-mini-combinations, system software, other off-the-self considerations)? For example as noted above, the terminals have already been decided upon through the RFP as principally alphanumeric with some graphic capability. However, much of the Army technical and combat training which exist now and probably more so in the future lend themselves to much more use of graphics than considered at the current time (especially for simulation work with expensive equipment configurations). This question also relates to the selection of course materials under the current Project ABACUS, as it relates to general utility in the Army and in other Services, as well. For example, if the configuration changed others would have to rewrite the course materials unless it is clearly shown that there is a reasonable and feasible relationship to some follow-on system. I have considered some of these hardware and software decision-making questions in two earlier publications and suggest they might be consulted for additional information. (See Seidel, 1973, and 1971, pp. 10-12, attached.)

With these provisos in mind, I will now address my comments to what seem to be relevant yellow flags raised at the two-day consultant conferened. I will try to confine myself to items which seem relevant to the Systems Group, however, many of these may seem may seem to overlap with the Training Group's interest and probably there will be a good deal of overlap with other consultant comments, as well.

Short-Term Goals

The first point to make here is that it is fully recognized that GTE Sylvania is providing the basic hardware and systems software as per the RFP specifications. I assume that this is not going to change. Questions can be raised, however, about the relationship between the course materials that will be written to test out the system's software (e.g., exercising the graphics capability, data base access) and the overall evaluation plan which is relevant to evaluating the cost/effectiveness of Project ABACUS. To date, there does not seem to be an established plan for relating the application software which is internal to the course and student evaluation to the acceptance test of the external software, or system software. It may, therefore, be quite relevant to consider revision of the Evaluation Plan to include incorporation of a link-up between the application software and the system software. This seems to become especially critical when we are considering a system which is now CMI-oriented as opposed to CAI-oriented. Even if it is not desirable to revise in any radical way the Class 1 language at this point, it may be extremely important to note the potential requirements for follow-on systems and where particular difficulties may arise (e.g., author formatting, methods for data access) given the current command structure of the language.

Another extremely critical item is proper course selection. The fact is that much of the research and development in CAI in the past has shown quite clearly that you can save 20% to 40% of a student's time in a course by (a) systems engineering of the course, and (b) using some form of programmed instruction. It is important to note that the candidate courses chosen at Ft. Gordon are already all self-paced. They therefore have shown, as indicated by our hosts, a good deal of savings, somewhere on the order of 20% already. In addition, the major portion of the current selected courses are hands-on, off-line, some 65% for example being performance-oriented portions of the course. Moreover, only 5% of the instruction is planned to be interactive through the use of the terminal. From our introduction to the three courses, dropout rates are extremely low already. It is therefore extremely questionable as to whether or not the addition of the computer can yield a greater savings in student weeks per course to warrant its inclusion as an add-on dollar investment in the delivery of the course to the student.

For political purposes, I would suggest that serious consideration be given to choosing non-self-paced courses as the initial candidates. At least one, high-density course with a relatively heavy dropout rate would help. I doubt that this change will cause much of a delay in the project's attainment of its final goal, since the materials currently being written are being prepared without knowledge and without full implementation of the software and hardware of the CTS. Note also that the acceptance tests have been delayed a number of months because of some already existing deficiencies in the delivery from GTE-Sylvania. Indeed, it may well be unrealistic to attempt to retain the original delivery date for the completion of Project ABACUS.

Along the same lines, to accomplish dramatic dollar savings, I would also suggest that the newly selected courses include a much larger percentage of soft-skilled kinds of instruction. This is particularly appropriate because the system does not seem to lend itself too well currently for troubleshooting or other equipment simulations. (Of course, exploitation of the graphics authoring capability may overcome this lack to some degree.)

Reconsideration should be given also to the question of whether in the 128-terminal system, all terminals have to be interactive terminals as opposed to splitting them between some interactive CRTs and some batch type printer terminal which would be less expensive and probably just as appropriate. The Air Force Advanced Instructional System development has a mix of such terminals and perhaps can be sought for guidance in this design area. The Air Force should be able to provide some additional guidance in the area of file structures and other resource allocations in a CMI environment since this is the specific thrust of their project.

Related to the cost-effectiveness discussion above is the fact that the one other way to make dollar savings in easy measurable terms is through the elimination of waste time for graduates in individualized curricula. The whole question of early assignment and prediction of early graduation would seem to require much more detailed inclusion in the evaluation plan. Public Law 51 can be circumvented. HumRRO papers a couple of years ago addressed that very problem. Secondly, a paper by Wagner of HumRRO dealing with the problems of modeling early prediction also suggested techniques then that today might be applied in the CTS project in order to better the predictive capability for individualized graduation and therefore individualized assignment. It would be significant then, if this project with the high visibility that it already attracts can get the DCSPER responsible individual (e.g., BG Stevenson), to cooperate in a mutually beneficial development at the national level to utilize more effectively the existing computerized assignment system. At least in the near term efforts should be made to get the CTS graduates from Ft. Gordon assigned to their job on a higher priority basis than a student from any other school, thus eliminating all existing delays. Dollar savings could easily be shown.

Long-Term Recommendations

In this section I will divide my remarks into three categories dealing with: potential future orientation of training programs in the Army, future delivery systems for new training orientation, and thirdly the relationship between those two new developments and a redirected curriculum research and development capability within the Army.

The first, rhetoric dealing with the new look of the volunteer Army, stresses the small number of personnel, the heterogeniety of personnel and the requirement for instantaneous upgrade or change in readiness posture. What follows is an attempt to deal with this set of requirements in a realistic manner. A concept of Army training presented by Colonel Howard at the Project ABACUS Conference concerned a three-dimensional matrix dealing with the focus on units, teams or individuals; locations at schools, units or National Guard and Reserve; and with various kinds of curricula. The old premise under which training was conducted seemed to be to bring all the trainees to the schools first, and then giving them OJT to make up the difference between what the school could not provide and what was required on the job.

I would suggest that we address Colonel Howard's matrix for the future by trying a reversal of that premise and ask what this implies for the nature of Army training. Obviously, it has the potential to bring the school to the student instead of the student to the school and make training more on-the-job than in-school (therefore increasing unit and individual training). Industry (e.g., IBM) has already cost-justified CAI training of their personnel in this manner. I would emphasize the value of three attributes: flexibility, decentralization, minimal travel for the Army. One of the hoped for advantages certainly would be lowered costs of training. An integral element in such an approach would be heavy use of the computer to facilitate delivery of instruction, to lower course development costs, and to aid personnel assignment.

Clearly, the implication is for (1) minimal travel and per diem costs by students (2) less numbers of schools, consolidated schools, fewer instructors, and therefore lower costs, (3) more spare equipment would be required for OJT, which probably would increase costs somewhat but (4) the latter probably would be offset by higher motivation for the students, since the training and the job would be principally collocated and therefore more meaningful training to the trainee. This would also imply that feed-in from training to job for the student, and feedback from the job to revision of training programs would be much easier, therefore facilitating course update and better upgrading of job requirements for the solider. It also would mean that refresher training and secondary MOS training could be provided, given that computer configurations with versatile terminals are available. For initial training outside CONUS, PL-51 will have to be considered but this should not be insurmountable.

Realistically, what kind of a formal mechanism would make such a proposal possible? For one thing, an amalgamation of the management of development projects involving computer aids and other technology aids to training at one site would facilitate the coordinated monitoring of a nationwide and worldwide US Army effort. A beginning apparently is already under informal consideration (e.g., placing CATTS, CTS and other technologies under a single directorate at Ft. Eustis). I would suggest that what is further needed is a formal management mechanism by which new R&D projects are intiated from the field; research and curriculum development projects can be conducted and completed at a center, avoiding thereby duplication of efforts with limited resources; and the available materials or findings given back to the operational field units and schools where applicable for pilot testing. Once field tested, materials could be delivered with computer assistance insuring a minimal amount of delay from concept to finished product. I think that this can be done with a functional orientation to efforts conducted at a centralized training research and development center (National Center for Instructional Technology). To accomplish these functions I propose an Integrated Training System Model (ITSM) which is described in detail in the attached paper.

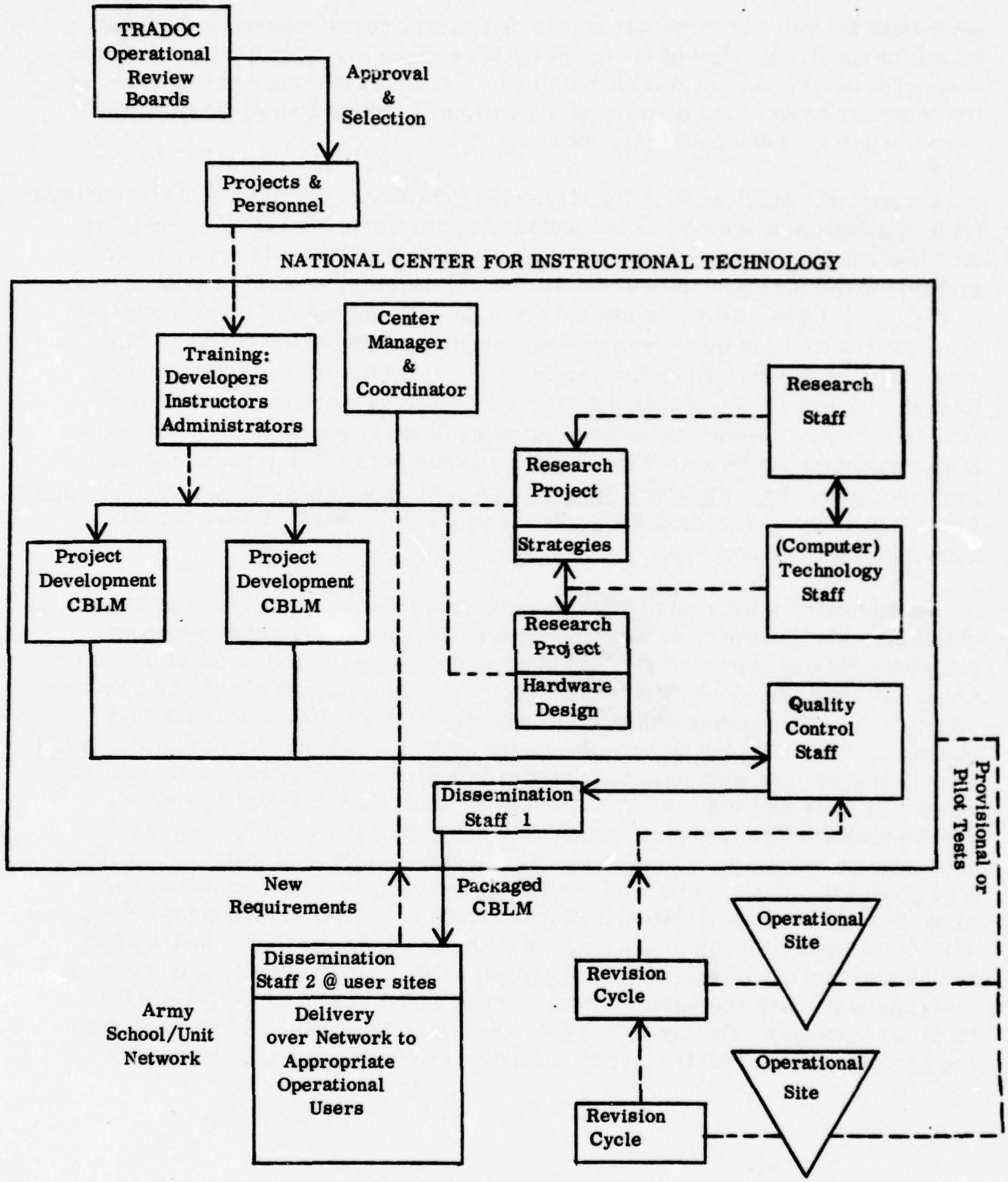

Figure 1. A proposed integrated Army Training System Model

user sites. Thus, the final package disseminated by the Center staff would not take place until there had been pilot testing and revision cycles had been gone through to insure a criterion having been met, such as the 90-90 or whatever else it might be.

e. The framework envisioned for the structure then of this Center would enable the Army to follow the guidelines embodied in the systems development cycle concept, and would further link comprehensive R&D programs with operational users. Parenthetically, it might be added that resources may become even more limited than is currently the case. Therefore requirements would exist for greater attempts at eliminating duplication across the Services. Consequently, a DoD level approach to this functional orientation would be desirable. It might well include ARPA as the coordinating body and would operate under the same logic except on a larger scale. The importance here is that with this approach the Army could certainly provide the leadership in this direction.

f. The overview presented above will be discussed in greater detail in the section concerning the system description of ITSM over the long haul. Specific management operations and research and development functions will be covered.

Objectives

a. To provide a framework and capability for (a) making the transition to cost/effective unit-oriented training, and (b) continued improvement and widespread implementation of individualized training facilities and systems.

b. To optimize within the ITSM framework the allocation of resources through sharing of Research, Development and Operational facilities and personnel.

c. To enable architectural growth of a CAI computer system which allows for a wide range of capabilities to be implemented, depending on the requirements of individual users (schools or units), and on requirements of new courses of instruction.

d. To use the results of early Army operational experience with the system, to continually improve the system design and implementation.

e. To provide the capability, if desired, to capitalize upon ARPA network facilities.

a. **System Concept**

(1) **Management Concept**

(a) The basic management concept integrates Operations and R&D under a third party Management group. The system is shown in simplest form in Figure 2. For convenience, the system will be called the Integrated Training System Model or ITSM.

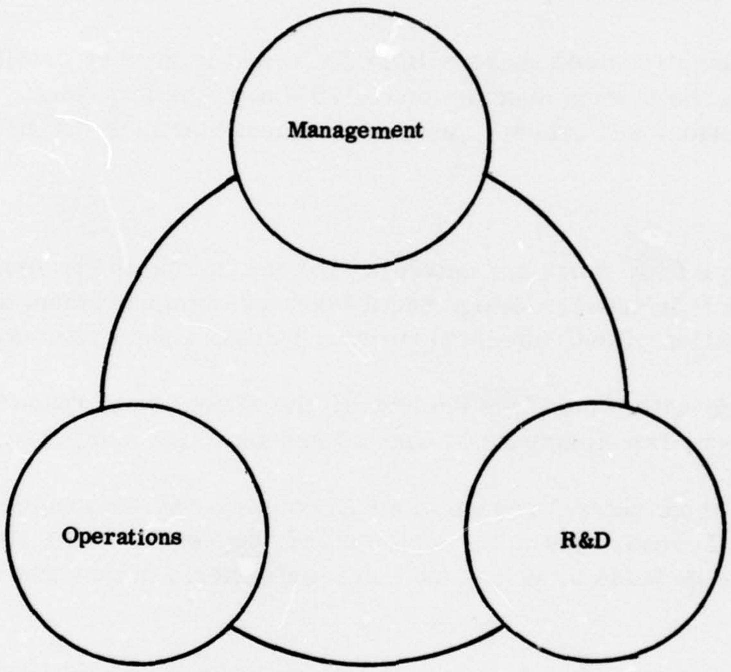

Figure 2. Basic management concept.

(b) A tentative organizational description of the system is shown on the following page as Figure 3.

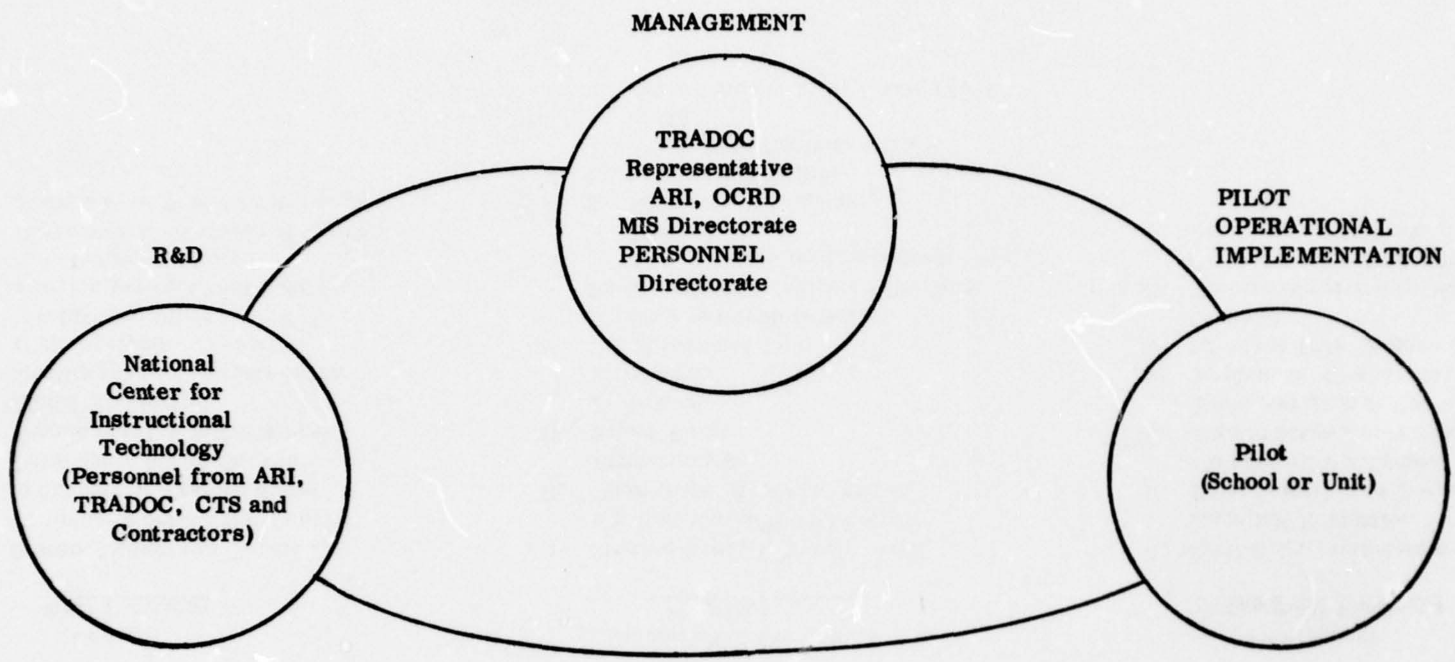

Figure 3. Pilot organization and major functions

Figure 3. Pilot organization and major functions (Cont)

Center R&D Functions

I. System Design and Tryout
II. Training of School Developers
III. In Support of Trained School Personnel, Initial Course Development & Instructional Model Application
IV. Quality Control of Instruction (Data analysis, formative evaluation, etc.)
V. Provide Instructional Input for New Language Design
VI. Automated Conversion of Course Materials to New Author Language

Management Committee Functions

I. Provide Overall Direction and Funding Expenditure Control
II. Coordinate Priorities and Procurement
III. Select Pilot:
   1. School
   2. Course
IV. Set Milestones for:
   1. Course Development
   2. Terminal & Computer Delivery & Installation (e.g. Anagraph Plasma, etc.)
   3. New Author Language
V. Recommendations for:
   1. Army Wide Implementation of CAI
   2. Establishment of In-House ITSM

Pilot School Operational Functions

I. System Implementation & On-Site Terminal Evaluation
II. Final Selection of Terminal for Complete Pilot System
III. Second Stage Course Development, Final Revision & Use
IV. Implement New Author Language
V. Interface Data Management With CONEDS
VI. Recommendations to Management Committee for Next Course Development Project

(2) This model illustrates the capabilities required to accomplish the specific activities described under Pilot Implementation.

(3) For purposes of short-term goals, the R&D Support function can be provisionally viewed as shown. The Management function may be vested in a mission-oriented committee. This committee might have the following composition:

. ARI Representative

. Management Information Systems Expert

. Subject-Matter Expert from the Pilot Site

. Personnel Expert from the Pilot Site

. DCSIT TRADOC Representative

(4) Operations functions are performed by the participating instructional staff of the Pilot Site. These suggestions are intended as context for interpreting the diagram, and not as firm recommendations. For discussion purposes these functions can be assumed to be carried out at Ft. Gordon with the implementation under Project ABACUS. Such an approach provides a framework for efficient solutions to implementing innovations: physically, financially and operationally.

b. Technical Concept

(1) The technical approach is characterized primarily by flexibility--both in the design of CAI computer systems and in the development process for such systems. For example, a new, multi-mini system might be designed as a true multiprocessing system. The system would distribute its resources dynamically among the several miniprocessors so that individual tasks can be performed in the most efficient manner. Thus, these processors would be designed to share functions; and a variable number of processors may be used, depending on complexities and number of terminals to meet school and course requirements. Findings of Project ABACUS would be fed back from the pilot implementation site to the National Center in order that they be incorporated into this new design effort.

(2) To illustrate further, the early operational capability feature of ITSM would enable Army personnel to develop skills and materials on terminals that might be used in a tested system. HumRRO experience has shown that CAI materials cannot be developed adequately on the drawing boards; that hand-on experimentation with operational features of the instruction and pedagogy, on a live system, are essential.

(3) An early operational capability such as Project ABACUS and its follow-ons in the proposed model would enable the Army to make in vivo comparisons of alternative technologies. How might an application of this approach be made? As an example of terminal comparisons consider that the Plasma panel is a very promising new technology. The Color Half-Tone Area Graphics Environment (CHARGE) terminal is a device (HumRRO) based on a new concept.

(4) The types of data available at present, on which to make a comparative evaluation of promising terminals, varies from case to case (e.g., CMI, CAI, high-graphics use, etc.). The ongoing studies are providing useful data re:Plasma Panel and PLATO IV. Project ABACUS will yield data from a more intensive prototype application at Ft. Gordon. However, in comparing costs, not only initial cost but operational costs must be considered. Operational costs include reliability. When the eventual number of Army terminal installations is considered (say 8,000 or even twice that), operational costs and reliability may make a difference of millions of dollars between one terminal type and another, even when initial purchase costs are comparable.

(5) Performance characteristics among terminals vary. The problem in comparing performance on paper is the inability to predict what the actual performance will be under operational conditions. The Army is interested in capitalizing on the latest technology developments to achieve an inexpensive, high performance, reliable terminal. However, the terminals using this latest technology must be thoroughly tested under operational conditions to assure that the performance characteristics will remain satisfactory with repeated use under full load conditions.

(6) Another dimension of performance, aside from engineering reliability, is the knowledge of the performance capabilities that are required by the application.

(7) The CHARGE terminal, for example, will permit dynamic color simulation of combat terrain or equipment characteristics and allow for continuous interaction. Different levels of detail and varied perspectives will occur as if the trainee were actually working in and around the real environment (and equipment). With the continually increasing complexities of new weapons systems which the soldier in the field will have to operate and maintain, the real cost-performance payoff from using computers in training will come from developing and testing new training concepts not heretofore available in the traditional instructional setting.

(8) Another way in which terminals must be compared is the environmental conditions required for operation. Ambient light and noise, air temperature, floor space, physical configurations of space--combined effects of all of these on the effectiveness of the learning environment--can only be learned through operational experience.

(9) A final area for comparison is that of computer system support requirements. The way in which a particular terminal system receives its input, generates characters, etc., affects the nature and amount of computer capability required for optimal operation of the terminal. This computer support must be figured into the overall cost of the terminal operation.

(10) With the ITSM approach, a base of comparative data could be built up of experience with various terminals operating in the same physical, pedogogical and technical environment. This empirical base would enable the Army to select the optimal terminal not only for the pilot system but for later installations as well.

c. Transition

(1) A short-term, mission-oriented ITSM might be employed to carry out the functions and activities described under Project ABACUS. Over time, the ITSM organization is expected to stabilize, take on expanded missions, and develop the in-house capabilities required to achieve its long-term objectives.

(2) Transition activities will be planned and implemented by the Army. These activities should represent a logical extension of activities initiated under Project ABACUS. They should result in an Army in-house capability fully responsive to emerging and future requirements for all training innovations. The computer applications are chosen here because of their immediate value and because they represent the leading edge of individualized training innovations.

(3) Activities illustrating the intended nature of the transition are given below.

(a) Designate a DA Steering or Project Advisory Group to study and recommend the nature of the permanent ITSM structure. This group would have membership representing the interests of DCSPER, OCRD, DMIS, and TRADOC. It could be an added function of the existing Project ABACUS SAG.

(b) Establish missions and functions for the permanent organization.

(c) Assign transition personnel to develop interim TD or TOE, and to identify permanent staff.

(4) Depending upon study results, the permanent organization may take a variety of forms.

(a) A central physical entity, such as a National Center for Instructional Technology, including facilities for instructor training, and a communications network (e.g., field representatives) encompassing selected TRADOC schools. (This alternative is illustrated in Figure 4.)

(b) A regional system, analogous to the "proponent school" concept, organized by computer applications, with both an inter-regional and satellite-school communications network.

(c) A decentralized system organized by subject-matter and/or MOS applications.

(5) Transition personnel would discharge their missions within the context of Project ABACUS. Recommendations for a permanent structure, its mission and functions, will perforce be influenced by operational experience with the pilot system.

(6) From the emerging experience, it may be possible to explore new options for operational and R&D components. For example, operational experience may justify, in some cases, selection of one or more maxicomputers, centrally located with minicomputers at the training sites. Where appropriate, the central computer(s) may store course logic or text, or provide computing capability, and interface with the miniconfiguration through a system comparable to the current ARPA IMP, or Interface Message Processor. This approach is intended to yield greater performance at equal cost.[1]

d. System Description-Long-Term Evaluation

(1) It is premature to project the exact structural nature of the emerging ITSM. However, the pilot implementation plan described earlier suggested major functions that are expected to remain important for an Army-wide ITSM. As before, these relate to management, operations, and support (R&D). The long-term success of the ITSM will depend heavily upon the integrity and cohesiveness with which these three functions are maintained. In order to insure that this takes place, it is proposed that overall authority for management and coordination be vested in a small committee with a rotating chairmanship. This group would be composed of DA level representatives from DCSPER, TRADOC, OCRD and DMIS. This is illustrated in Figure 4.

(2) This section suggests some functions to be performed by the three components in the long-term ITSM. Figure 4 illsutrates how these functions would be implemented in terms of both the flow of products through a National Center, as well as personnel. Figure 4 should be used as a companion to Figure 1. The

[1] "Current Status of Computer-Administered Instruction Work Under Project IMPACT, by Robert J. Seidel, Human Resources Research Organization, Alexandria, VA., Professional Paper 18-72, July 1972.

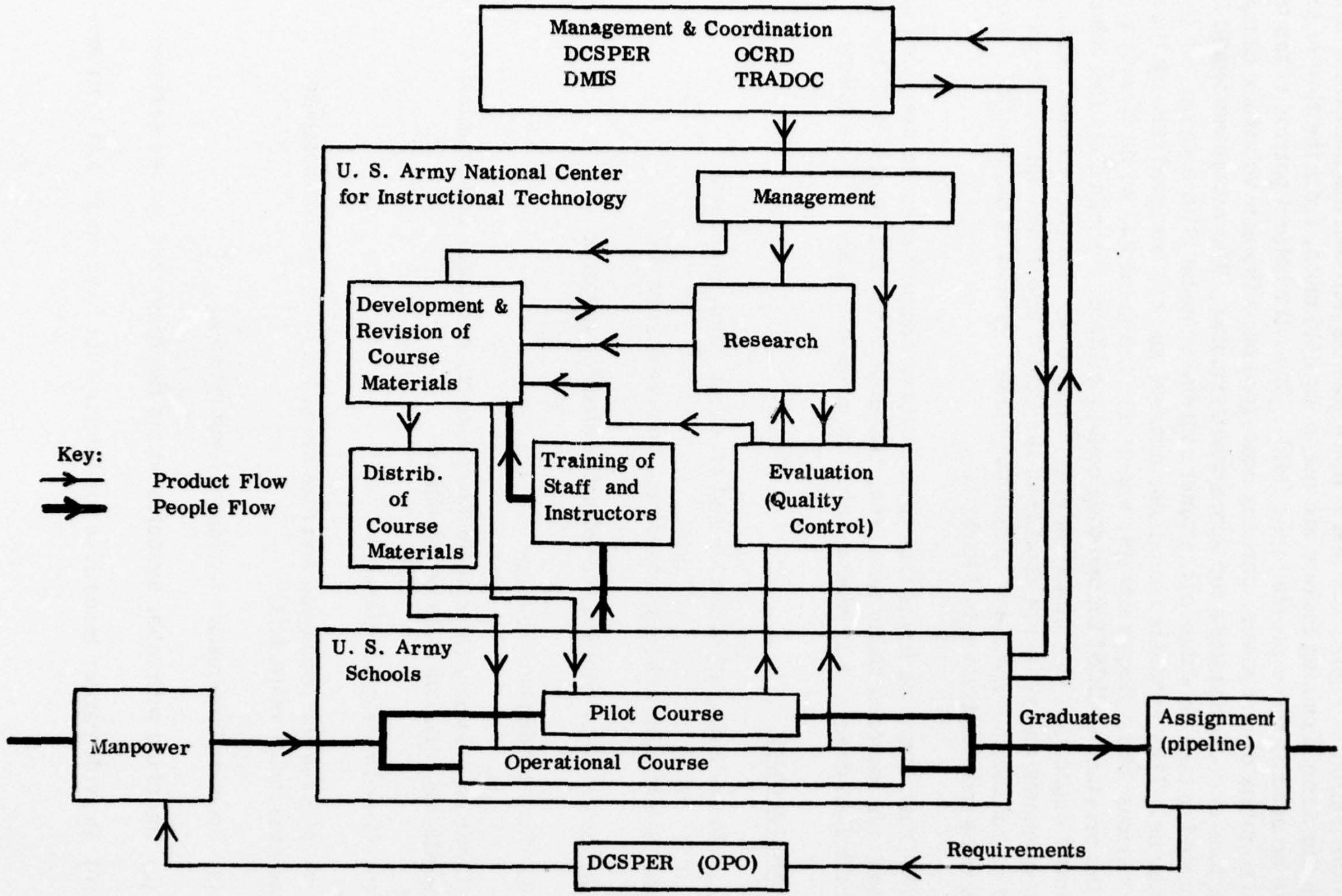

Figure 4. Illustrative flow of products and personnel through the ITSM.

added information in Figure 4 is that it distinguishes between the manpower flow through the Army Training System and out to its field units, from the flow of products to be used by these people in the field. Thus, the bottom portion of the figure shows the influx of manpower, perhaps conceived of as the new volunteer Army, into various schools and units for appropriate training. The manpower would then be allocated to take on either operational courses or some pilot courses, as the case may be. They graduate from these courses and are assigned through the pipeline to various jobs. Requirements, vis-a-vis assignments, would clearly come under the province of DCSPER and they could facilitate, through their individualized assignment capability, the allocation of new manpower into various units and schools. The development and research aspects of the Center are somewhat telescoped in Figure 4, but they nevertheless contain the same functions in the form of a product flow as does the illustration in Figure 1.

(3) The remaining items then to be covered concern specific examples of functions to be covered under Research, Development, Management and Operational Use of the Personnel and Products within the proposed ITSM. These follow.

e. Management

(1) Provide overall direction and establish Army standards.

(2) Select pilot schools; coordinate selection criteria.

(3) Select pilot courses; coordinate selection criteria.

(4) Insure adequate funding.

(5) Set milestones for course development, computer and terminal delivery and installation, and software development.

(6) Coordinate priorities.

(7) Manage the packaging and dissemination of completed computer-oriented curricular materials.

(8) Sponsor information exchange conferences.

(9) Interface with other agencies within the Army and across services.

(10) Provide career incentives for Curriculum Developers and Instructors.

f. Operations

(1) Provide operational test sites for prototype products (hardware, software, instructional materials and strategies, and operating procedures).

(2) Implement and maintain prototype systems.

(3) Provide evaluative information at various levels, e.g., cost/effective data on operating systems and terminals, and other feedback regarding course materials, student management, and assignment procedures.

(4) Maintain liaison with support and management elements through such mechanisms as clearinghouses and centralized system support capabilities.

g. Research

(1) Conduct experimental studies in:

(a) alternate instructional management strategies;

(b) techniques for the systematic development and revisions of instructional materials; and

(c) alternate hardware and software designs.

(2) Participate in the design, test, and evaluation of alternate computer configurations.

(3) Develop alternate models for the management of individualized training in the Army.

h. Development

(1) Develop, test, revise, and disseminate computer-oriented curricular materials of all appropriate types (e.g., mainline tutorials, problem-solving, gaming, drill and practice, and simulations).

(2) Provide quality control standards for the development, documentation, and dissemination of such materials.

(3) Specify the parameters for an individualized training management system (e.g., student scheduling, staff incentives, accounting procedures, and individualized graduation and assignment).

(4) Specify parameters for implementable delivery systems (e.g., type of hardware, number of terminal/school, and software facilities).

(5) Conduct continuing formative evaluation studies in school environments.

(6) Provide instructor training in the use of computer-oriented curricular materials.

(7) Results of the recent survey (by Rich and Van Pelt, 1974)[1] of Army CAI reveal fragmented efforts with no apparent coordination, very similar to the cottage industry in civilian education.[2] The ITSM approach including the proposed National Center for Instructional Technology would provide the necessary management and technological directions for the Army to maintain leadership among the Services in training R&D. It would also yield a feasible model for making the transition from a totally school-based operational training system to an advanced cost-effective, unit-oriented program.

i. ITSM Potential for DoD

(1) Finally, as indicated earlier, the same logic which makes the ITSM appealing within the Army could be applied at the DoD level on a larger scale. This section describes a possible extension of the ITSM to include a Joint Services Human Resources Institute.

(2) The basic purpose of such an institute would be to coordinate and develop a cohesive research and development program relevant to the efficient use and increased capabilities for the individual military person. Problems which have beset behavioral science efforts to date within the military services have in large part stemmed from the need to compete with one another for limited funds and to attempt duplicative or parallel developments when at the outset the funds were not sufficient to accomplish even partial goals which were set by the particular Services. What this means is that each Service will have an opportunity to contribute ideas, concepts, directions relevant to its perceived unique needs, while at the same time benefitting from a unified, multidisciplinary effort physically located in one structure and providing the flexibility, growth potential and continuity in resources. The perceived necessity for studying all facets of a training problem

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[1] "Survey of Computer Applications in Army Training," by Joseph J. Rich and Kermit B. Van Pelt, Computerized Training Systems Project, Ft. Monmouth, NJ, Interim Report, August 1974, CTS-TR-74-3.

[2] Learning Alternatives in U. S. Education: Where Student and Computer Meet, by Hunter, Kastner, Rubin and Seidel, Educational Technology Publications, Inc., January 1975.

by each Service will be eliminated. The hardware or software subsystems which would be necessary to deal with any use of the computer or other educational technological innovations can be handled just once without the necessity for reinventing different concepts--the same concepts--at different locations and in different Services. Evaluation of emerging techniques and technologies can be made for the benefit of all in a coherent manner. Thus, for example, the Plasma panel which might be considered the most innovative hardware feature in the way of student terminals for computer-administered instruction could be compared dispassionately in a deliberate series of studies with other potential competitive innovations such as the storage tube approach to improvement of CRTs and graphic capabilities. Exploitation of the ARPANET as a delivery system for the Services would be a natural task in this context.

(3) The framework envisioned for the structure of this institute would follow the guidelines embodied in the systems development cycle concept and would indeed, furthermore, link comprehensive research and development programs with regional applications research centers representing the four Services. This means that the initial steps in the cycle, that is the determination of the needs of the various Services, would be provided by them as feed-in to the Central Research and Development Institute (CRDI). Following this, representatives of the Services involved with the particular problem would translate, at the Central Institute, the needs into firm objectives for exploratory investigation. Alternative experimental configurations would be tried out and finally, when the step of implementation is reached in the systems development effort, a preliminary development would be tested within the Regional Applications Center of the original requesting Service. During the time of development, assessment would be continually made concerning the applicability of a particular problem and potential solution for the other services. And when the point of implementation is reached, the continued guidance during the systems development cycle provided by the other interested Services could also lead to a simultaneous implementation at another Regional Center relevant to the other interested Service(s). A good example of this type of joint involvement with mutually beneficial results is the problem of dealing with individualized graduation and assignment to a particular job or MOS following training. The overall model, a type of traffic control model, most probably would be the same for all the Services. What would differ would be the data points, the MOS category, or the particular parameters for assigning individuals to a given military occupational speciality versus some other possible category of job relevance. In addition, certain characteristics of schools would be unique from Service to Service. However, in the main the overall nature of individualized flow through an instructional system (the algorithm) with individualized assignment following would pretty much be equivalent in form regardless of Service. Clearly, the joining of forces would permit a much more massive attack on the problem and also the Services would benefit from the input that the others could provide as well as themselves. (Both in terms of personnel with given expertise, as well as facilities and other resource capabilities.)

(4) The proposed structure would be as follows. The Central Research and Development Institute would be comprised of a cadre of representatives, technical and administrative, from each of the Services. For the most part these would be civilians to provide the necessary continuity of effort. At the Central Institute there would also be capability for visiting civilian researchers. Management of the Center would be flexible and permit the letting of contracts to conduct many of the studies identified by the Services as necessary to provide for their unique problems. The management of the Regional Centers would be mission-oriented and provided by the particular Service for whom that Center is created. The researchable ideas and problem should flow in two directions. Thus, Regional Centers as a result of their more closely allied operational contacts would be able to provide insights for problem identification, the solution of which might best be satisfied at the CRDI. Moreover, it is important that a bi-directional feedback system be provided for in this network arrangement. Obviously, the importance of this overall concept is to provide the necessary linkages between research, development and operational utilization. While the emphasis obviously is to be placed upon efficient personnel utilization and career development, the areas for investigation must include related fields bearing directly upon these problem areas. Thus, for example, as noted above in the field of CAI language development, systems software, computer developments and student terminal improvements and modifications must be considered.

(5) A number of considerations remain to be answered. Some of the more important ones are who will direct the policies and planning of this network? Will it be direct from OASD Manpower, or will there be a type of Joint Chiefs of Staff arrangement? Will the annual funding for such a network be an add-on item to each Service's R&D budget, or will it be composed of contributions provided from the already existing annual budgets? What will be the management relationships between the Regional Centers and the CRDI? What will be the nature of the relationships between in-house work and contracting studies?

(6) Once these questions are answered, a DoD-wide ITSM could become a feasible reality. In an analogous way to the Army approach, the proposed Joint Services Human Resources Institute would provide the necessary management and technological leadership to accomplish a cost-beneficial model for a continuing, innovative DoD level training system.

Biographical Sketch

Alexander Schure Ph. D., Ed. D.

1. PRESENT OCCUPATION - President - New York Institute of Technology
   Chancellor - New York Institute of Technology, Nova University Federation

2. BIRTHDATE - August 4, 1920

3. IEEE MEMBERSHIP GRADE - Senior Member

4. EDUCATION

Educational Institution	Location	Degree	Year
Washington University	St. Louis	A. S. T. - EE	
Pratt Institute	New York	A. S. T.	1943
C. C. N. Y.	New York	B. S.	1947
N. Y. U.	New York	M. A.	1948
N. Y. U.	New York	Ph. D.	1950
N. Y. U.	New York	Ed. D.	1953
Nova University	Florida	D. Eng. Sci. (Honorary)	1970

5. PROFESSIONAL HISTORY

From (year)	To (year)	Name of Company	Position Held
1970	present	*Nova University, Ft. Lauderdale, Florida	Chancellor
1955	present	*New York Institute of Technology	President
1951	1955	**Crescent Electronics Corp.	President
1948	1955	** Crescent School (N. Y. Technical Institute)	President
1945	1948	Melville Radio Institute	Asst. Director

*Concurrently, from 1970-present; **concurrently, from 1951 to 1956.

a. In July 1970, Nova University appointed Dr. Schure as Chancellor.

b. In 1955, Dr. Schure was one of the principal founders of New York Institute of Technology.

c. From 1951 to 1956, Dr. Schure served concurrently as President of Crescent Electronics Corporation.

d. Dr. Schure began his professional career in education as an Asst. Director in the Melville Radio Institute in 1945. In 1948 he founded the Crescent School in Brooklyn, N. Y., which subsequently acquired title and properties of the N. Y. Technical Institute.

Recommendations Relating to the ABACUS Project

by

Alexander Schure, Ph. D., Ed. D.

The following sets forth an outline of the research areas, both long and short term, that in the opinion of this consultant are imperative to the success of Project ABACUS. The areas are all related to the capabilities and facilities of the computer or its peripheral equipment. All of these items have been found to be essential in the preparation of smooth running and meaningful computer supported instruction. Research relating to each should prove fruitful. Each heading in each numbered paragraph indicates a research area to be investigated. Rationale for the selection of such areas follows:

Hardware

a. Programming Languages. Since dependence should not be placed on programmers who have little or no experience with either the subject being developed or the pedagogical procedures that are the most satisfactory, instructors should be trained to do their own programming. This calls for the use of a simple programming language, yet one which has the necessary power and versatility. EXTENDED BASIC has been found to be eminently satisfactory for non-graphic programs. Now, for full graphic capabilities, APL is generally recommended. Continuing research into program language improvements is a necessity.

b. Response Time. Computers tend to slow down as the student load increases. In choosing the hardware, consideration must be given to the heaviest anticipated load so that a very fast response can be expected. Boredom sets in very quickly when students have to wait for continued program execution after each input. Reduction of response times under heavy computer loadings is a requirement for large scale systems.

c. Reliability. Down-time must be reduced to a minimum. For most efficient use of terminals, student time-scheduling is of paramount importance. When a student loses a session due to computer malfunction, even temporary standby conditions, it is difficult if not impossible to make it up.

d. Backup. The system should make it possible for instructors or departments to copy completed non-volatile programs on magnetic tape (or a suitable substitute) to avoid loss of the programs if files are destroyed during a crash.

e. Terminal-to-Computer Linkage. Although the use of telecouplers and modems is a useful expedient when the system is not hard-wired, it is very expensive and inconvenient. Any planned installation should take into account the

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need for a suitable cable for this linkage. This is a matter of judiciously selecting the locations of the CPU and the peripherals with respect to the terminal sites. Investigation for solutions of this problem is a fundamental of all planning stages in extensive installations.

f. High-Speed Printing. Although many CAI procedures depend only on terminal printouts, the availability of a high-speed line printer is a necessity if only for backup purposes. This applies particularly to drills and test; regardless of the number of such items stored on disc, every instructor must have available preprinted copies of the software in the event of system failure when drills and tests are due to be administered.

g. Student Terminals. The structure of the student terminals for and to optimize training requirements is another arena. Video versus hard copy is the big question. At present, it is easy for a student to carry out copies of tests and problem exercises if a hard-copy terminal is used. Instructors should have access, however, to either a hard-copy terminal or a video terminal equipped with a termal printer or substitute. It must be made very easy for instructors to obtain student, class, and course reports from the computer's files and equally easy for students working with video terminals to obtain hard copy when required.

h. Editing Facility. This is a matter of hardware selection as well as programming. A highly competent intrinsic editing system should be part of the inventory of the facilities of the system. (For example, the XEROX SIGMA 6 and the XEROX SIGMA 9 are both equipped with a remarkable editing facility). Changes in course content, an inevitable outcome of data accumulation, will be postponed or never made at all unless the editing facility is very fast and very easy to use !

Software Organization

a. Training Exercises. The ability to typewrite is assumed, even by the hunt and peck method. However, certain basic skills in using a computer terminal must be developed in the student; use of the rub-out key, control-X, escape-R, etc. to protect him from being downgraded despite his recognition of errors immediately after typing and before carriage return; logging-on and logging-off procedures; numerical calculating in the keyboard mode; etc. One or two preliminary exercises should be prepared for these items.

b. Prime or Supportive CAI?. This is always a debatable question. Prime CAI attempts to do all or most of the teaching by the Socratic method; supportive CAI relegates the teaching to competent people in a conventional or unconventional classroom using live demonstration equipment and other audio-visual aids, and is employed to enrich, exemplify, fill-in, drill, test, etc., the material provided by the teacher. A decision relating to this question must be made in the planning stage. Research relating to training optimization will assist the planner.

c. Teacher Training. Aside from learning to write programs in his own field, the teacher should be trained with respect to the philosophy, techniques, and strategies which best apply to the particular nature of the content with which he is working. Only when the staff or faculty actively participates in these tasks can maximum success be expected.

d. Format of Exercises. The subconscious reaction of a student to the format of the material he sees on the screen may be likened to any reader's reaction to a careful published layout in a textbook or magazine. Just as publishers strive for artistic appeal, the CAI programmer should aim for proper indentations, double spaces where needed, underscores, equations that look just as they do in books, and so on. This is not a fuss-pot attitude at all. The student will get the feeling that the course designers have taken the time and trouble to give him something appealing rather than just slapping anything at all into the program.

e. Design for Minimum File Space Requirements. It is much easier for the student to read expository material from a clearly printed sheet of paper than it is to grasp it as it prints out on the terminal screen. Moreover, disc space depletion can occur very rapidly when a great deal of text is written into the program. The use of Worksheets and Question/Problem Books minimizes both of these problems in representing the state of the art. Alternatives should be studied.

f. Software Categories. Supportive CAI software takes a number of different forms, both from the point of view of the motivating philosophy and presentation styling. Categories which explicitly describe the nature of the exercises should be set up early in the planning. As examples, categories include drills, tests, self-diagnostic problems, managed-problems, situational simulations, laboratory simulations, etc.

(1) Each of these groups should be further categorized in terms of function, that is, is the exercise in a given group to be required of every student or might it be optional for some or all of the learners?

(2) A level-of-difficulty rating should be assigned to each exercise as well. The first judgement is intuitively based, but as data is gathered, these intuitive classifications may be readily changed as required. The material complement of several different courses in the same field may then be properly adjusted in classifications such as basic and advanced.

g. Motivational Research in Student-Computer Interaction. This is one of the most important research aspects relating to CAI structuring. After the novelty wears off, the computer is often an extremely dull lecturer! Its value lies in its ability to elicit student responses, analyze them for correctness, define the "hangup" that led to the incorrect response, remediate with explanations, and finally prescribe further student activity. Simultaneiously, records of the nature and characteristics of the responses may be filed for use in evaluating performance and achievement. Some further advantageous research techniques relating to and involving interaction -- always applied in tune with the nature of the subject matter and the objectives of the exercise -- are:

(1) Student participation in data selection. In certain types of self-diagnostic problems and in many situational simulations, the student can be made to feel that he is personally immersed in the activity if he is allowed to choose his own data (within carefully stipulated ranges) for the exercise. The computer then works with him on a one-to-one basis, analyzing his data as though it were dedicated only to him.

(2) Student participation in selecting calculating mode. The student should always be permitted to perform calculations in problems and laboratory simulations using his favorite tool. He may want to solve a problem longhand with paper and pencil, with arithmetical tables or log tables, with a portable electronic calculator, or by using the keyboard-calculator mode of the computer. This last mode, however, does call for preliminary training (Software Organization, a., Training Exercises.) which involves learning how to rephrase mathematical equations in acceptable computer-input format. As an important option, the keyboard calculation facilities should always be available to the student at any time during program execution.

(3) Student participation in Socratic development. Normally, the "teacher" asks a question to which the student responds and is remediated if necessary. Very interesting programs can be prepared, however, in which the student must ask questions of the computer and utilize the answers he receives in completing the exercise. This kind of challenge is quite different from the conventional ones and invariably heightens interest.

h. Reduction of Terminal Time. For reasons previously delineated, individual learner terminal-time-per-session should be reduced to as small a practical figure as possible. Suggestions for realizing this objective are:

(1) Confine the exercise to a single concept, if possible.

(2) Plan the exercise so that the student may prepare for it on his own time, away from the terminal. Basically, this means that he can prepare drawings, read schematics, solve equations literally in anticipation of data to be delivered on-line, take voltage or current measurements, and in general, ready himself to work quickly and efficiently once he logs on. This approach is especially good for problems in which constrained randomized data is given only after program execution has begun.

(3) Plan the exercise so that the student can complete the exercise away from the terminal after the program has been run. This applies particularly to simulated laboratory exercises in which a number of related questions and problems are presented on the laboratory worksheet.

(4) For advanced training situational simulations involving calculations as well as for problems and laboratory simulations, students should be taught how to solve an equation for the unknown in literal terms. This speeds up the process of keyboard calculation once the data is delivered on-line. This is particularly appropriate to the subject material like the Fort Monmouth course "Communications - Electronics Systems Engineering".

(5) All of these suggestions for reduction of terminal time are based on the meticulous preparation of alternative materials (video, printed worksheets,) etc., issued to the student well in advance of his scheduled appointment with the terminal.

i. Data Files. The computer files must be set up in a manner so that a variety of printed reports may be elicited any time, on demand of the instructor or department head. As a minimum, the files must be capable of yielding well-formated, unambiguous reports on things like:

(1) Individual Student Performance giving figures on error percentages, types of errors (in terms of needed skills), time-per-session, response time for critical questions and problems, rate of progress related to total course time, etc.

(2) Individual vs. Group Performance giving figures on rank in group based on rate of progress, rank in group based on grades obtained, comparative performance in terms of skill categories to locate specific skills which have not adequately developed in specific instances, etc. This data should also be able to provide reports for item analysis of course material in order to validate each item objectively so that the course may be edited for improvement, and so that level-of-difficulty ratings previously assigned intuitively may now be revised empirically.

(3) For both (1) and (2) above, research in the broader field relating to the type of statistics valuable to the trainer is indicated.

j. Tutor Contact. The complete system should provide for tutorial contact at the time that it is needed. A student should be able to confer with his instructor, peer tutor, etc. before, after, or while he is on line.

k. Reduction of Programming Time. A truly critical item!

(1) An effective CAI system cannot consist of a few isolated programs to which the course study guide refers only occasionally. It must form an integral, consistently applied link in the chain of events for each lesson or module. This means that a relatively large number of programs must be written for each course and in each category. Herein we encounter the most serious obstacle in the preparation of a CAI program. This problem can be completely circumvented by using the "variant-invariant" approach.

(2) In this programming procedure, a very carefully structured invariant section is written, including all of the content material that will appear consistently in all of the exercises. About 75% of each exercise is covered by the invariant section. A special worksheet is then prepared and reproduced in quantity in which only the line numbers that need to be changed for a specific exercise are shown. Insertion instructions are given for each missing line so that the information may be written in longhand. A typist then inputs this information and merges it with the variant portion of the program right at the terminal. The complete program is then saved under its appropriate file name. For example, the efficiency realized by this method permits an instructor to write a new computer-managed problem, complete with data-randoming instructions and a full set of terminating diagnostic questions for on-line student responses, in from 2 to 3 hours. Using the format worksheet, the typist can then input the information, merge the programs, check the operation, and edit the program in less than 2 hours!

l. Student Self-Diagnosis. All CAI exercises should contain a set of diagnostic questions for use on-line. It is here that correction, remediation, and prescription takes place in most categories of exercises. For the most part, these questions should be non-numerical to avoid excessive terminal time, but they must be expertly phrased and remediated so that they have conceptual value.

m. Software Category Characteristics

(1) Drills. randomly selected questions from an appropriate BANK; immediate feedback of correct answer after student response; records kept of responses for data accumulation only, that is, student course grades are not affected by drill results. This encourages learners to run through the drills. Limitation of the number of drills permitted per lesson or module at the discretion of the instructor.

(2) Tests. resemble drills in organization except that the student is not informed of the correctness of his answers until the test is finished and he signals termination. Normally, a weighted grade (based upon the conglomerate level-of-difficulty ratings for the questions on the particular test) is printed out on termination, but the instructor has the facility of test replay for his or his student's edification. All responses are recorded and accumulated.

(3) Situational Simulations. A situation is described in an imaginative and interest-stimulating manner in the Worksheet, and the problem is posed. The data may be randomly provided by the computer or the student may be permitted to select his own data, depending on the nature of the subject matter. The student is expected to show, on his Worksheet, the relevant equation solved literally for the unknown in both standard mathematical form and in computer-input form. Keyboard calculation mode is available.

(4) Laboratory Simulations. A self-imposed restraint operates here; a laboratory simulation exercise is suggested whenever physical conditions, cost, or non-availability do not permit it to be performed individually by the student in a live laboratory! The computer cannot replace hand-on laboratory work. It can, however, provide valuable training in pre and post laboratory procedures in instances where the equipment and/or supplies that would be needed are impractically bulky or costly. For example, very successful laboratory simulations have been written based upon experiments with 3-meter air tracks, particle accelerators, cloud chambers and bubble chambers, complex organic synthesis in chemistry, diagnostic situations in medicine and dentistry, electronics, avionics, etc.

(5) Computer-Managed Problems. Generally used to provide problem practice and a means for identifying student shortcomings in approaching computational problems. It is in this category that the "variant-invariant" procedure probably finds its most valuable application.

n. Reduction of Overall Training Time by Computer Techniques. Lessening of total training time to attain an MOS with high student proficiency is a prime military objective. In critical military situations, it has a priority higher than cost reduction.

o. Reduction of Training Costs through Computer Techniques. The stringencies of present budgets makes elaboration unnecessary.

p. Performance Agenda Items. Amidst the research, the following "performance agenda items" should be included:

(1) The model should "remember" student's performance on previous activities requiring similar skills, in order to guide and select strategies.

(2) Interface system with student's instrumentation to permit analog-to-digital input into ABACUS, with consequent guidance provided by the system.

(3) Extend above concept to the point of full failure simulation, with computer-controlled guidance toward problem solution.

(4) Record rate-of-progress data, so as to detect unusual changes in student performance due to curriculum mis-design, or due to student mis-understanding.

(5) Analyze types of skills required for successful achievement on each test (particularly the "hands-on" evaluations). Record achievement level for each skill type, during evaluation. Correlate with other tests of that skill type for the individual student, and with the performance of other students on that test.

(6) Record and correlate student learning style characteristics, across course boundaries. Incorporate data from initial military test battery, and use course evaluative information to update data from battery.

(7) Design an overall educational management information system which incorporates all of student's test information as well as personnel data. Should facilitate curriculum redesign process.

q. Overall Summary. In overall summary, the larger research areas deal with with motivation, better hardware, better software, better language, better simulation, and overall techniques designed to optimize individual learning experiences for the military student with reduced training time and costs.

Biographical Sketch

Lawrence M. Stolurow Ph.D.

1. PRESENT OCCUPATION - Executive Director, Institute for Research in Learning and Instruction, State University of New York at Stony Brook, Stony Brook, New York 11794

2. EDUCATION

Educational Institution	Degree	Year
University of Minnesota	B.A. Psychology	1940
Cornell University	M.A. Psychology	1946
University of Pittsburgh	Ph.D., Experimental Psychology	1947

3. PROFESSIONAL HISTORY

From (year) To (year)	Name of Institution	Position Held
	VIC (Vision Information Center), Massachusetts General Hospital. USOE Project. US Public Health Service.	
1968 - 1969	University Information Technology Corp.	
1961 - 1966	University of Illinois	Prof. of Psych. and Ed.
1957 - 1961	University of Illinois	Prof., Institute for Rsch on Exceptional Children
1955 - 1957	US Government, Chanute Air Base, Ill.	Dir. of AF rsch unit dealing with personnel & training problems
1951 - 1955	University of Illinois	Dir., Tng Rsch Lab, Dept. of Psych.
1947 - 1951	University of Pittsburg	Assoc. Prof., Psych.
1942 - 1946	US Army Air Force	CPT, Aviation Psychology in the Army Air Force

4. ACTIVITY SUMMARIES

Taught undergraduate courses at Cornell University, University of Pittsburgh; taught graduate courses at University of Pittsburgh, University of Illinois, Stanford University, University of Pennsylvania, Harvard University, and SUNY at Stony Brook.

5. PROFESSIONAL MEMBERSHIPS

American Association for Advancement of Science (AAAS).
Member of Xi.
American Educational Research Association (AERA).
American Association of University Professors (AAUP).
International Reading Association (IRA).
Association of Computer Machinery (ACM).
Association for Educational Communications and Technology (AECT).

6. PUBLICATIONS

Published four books and over 100 articles, reviews, and monographs.

FORMATIVE EVALUATION:

AN EMPIRICAL DECISION PROCESS [1]

Lawrence M. Stolurow
SUNY at Stony Brook

Robert L. Brennan
SUNY at Stony Brook

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1 Submitted for publication in the Proceedings of the Fort Gordon Conference on Project ABACUS, Sponsored by Army Research Institute.

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Introduction

a. The ABACUS program is clearly shifting from a CAI to a CMI emphasis. This is creating a need to re-examine the R&D program to make it consistent with the new emphasis. This paper is an attempt to look at one problem in this context, namely a part of the formative evaluation process. This paper provides a meta-model for use in the CMI application contemplated at Fort Gordon. It builds upon the authors previous work with the U. S. Naval Academy and provides workable algorithms for processing data from student performance. The processes of data analysis are designed to support a decision maker who is responsible for the quality of the instructional program. The procedures are described at a level which will permit them to be used directly in a variety of contexts. They are not just for a particular training program.

b. The rationale for this paper is that it consolidates, in a decision context and in a more rigorous form than is now available, the processes that provide the bases for changing a system of instruction. By systematizing these processes and building them into a program, a process of iteration and validation can be started, and it can converge on a level of quality specified by the system managers. A CMI software effort could be developed to use CTS as the primary agent in this process. This will require programming and further development and testing of the concepts and decision processes included here.

Background

a. During the past decade evaluators of programmed instruction and computer aided instruction have recognized that it is very difficult, if not impossible, to determine subjectively the effectiveness of test items and instruction. (See Rothkopf, 1963.) In this paper we specify a set of objectives rules, based upon item performance data, for identifying those test items and sections of instruction that seem to require revision. This objective method should provide a more rational basis for decision-making than the subjective method of making decisions based primarily upon some unidentified combination of subject matter knowledge, experience, and intuition.

b. The rationale for decision-making that we propose is basically an elaboration of a technique devised by Stolurow and Frase (1968). Their method is based upon a comparison of three different types of error rates for program frames: (a) the theoretical error rate, which is the error rate expected simply on the basis of random guessing; (b) the base error rate, which is the error rate obtained by students not exposed to the teaching material for the frame; and (c) the instructional error rate, which is the error rate obtained by students who have been exposed to the instruction.

c. In this paper we will treat not only program frames (i.e., test items) that are an integral part of instruction, but also test items that occur both before and after instruction. In addition, we will use both error rates and discrimination indices as data for decision making.

d. In order to put the proposed decision process into a conceptual context, let us assume that we have an instructional program teaching a set of terminal objectives. Chronologically, each terminal objective is tested by (a) a pretest item that occurs before the objective has been taught, (b) a terminal test item that occurs almost immediately after the objective has been taught, and (c) a posttest item that occurs "some time after" the objective has been taught. Without loss of generality, we will assume (as is usually the case) that the set of pretest and posttest items form two tests that occur, respectively, prior to and following the instruction for all objectives. Furthermore, we will assume that all of the items testing any objective are either identical or "corresponding". (The concept of "corresponding" items will be treated in detail later; however, we can roughly define corresponding items as items that test the same objective at the same level of difficulty.) Given this conceptual context, it is clear that most forms of individualized instruction (including PI, CAI, and multi-media modes of instruction) can, and often do, meet these minimum requirements.

e. In the final analysis, using item performance data, we want to identify those test items and sections of instruction (relevant to a given objective) that require revision. The decision process we propose will not necessarily tell the evaluator how to revise items and/or instruction, but the process will provide objective rules for deciding <u>what</u> to revise.

Types of Data and Decisions

Error rate is defined as the proportion of students getting an item incorrect, i.e.,

$$\text{Error Rate} = \frac{\text{Number of Incorrect Answers}}{\text{Total Number of Answers}} \quad (1)$$

or

$$ER_i = \frac{N - \sum_{j=1}^{N} X_{ij}}{N} \quad (2)$$

where ER_i means error rate for item i, N is the total number of students answering the item, $X_{ij} = 1$ if student j gets item i correct, and $X_{ij} = 0$ if student j gets item i wrong. We can also express Equation 2 as:

$$ER_i = 1 - \frac{\sum_{j=1}^{N} X_{ij}}{N} \qquad (3)$$

Since the last term on the right of Equation 3 is item difficulty level (DL_i), it is clear that

$$ER_i = 1 - DL_i \qquad (4)$$

Equation 4 shows that from a theoretical viewpoint it is immaterial whether we use difficulty level or error rate; however, in our opinion, using error rate seems to facilitate an understanding of some of the decisions that will be proposed later.

f. For many of the proposed decision rules we will assume that error rates are classified as either high (H) or low (L), and that the evaluator predetermines an appropriate cut-off point between high and low error rate. For any given objective, the cut-offs for the error rates discussed below must be identical in order to apply the rules that will be specified. Also, in most cases, the cut-offs chosen will probably be the same for all objectives; however, occasions can arise when certain objectives should have a higher (or lower) error rate cut-off than other objectives. For example, items testing very crucial objectives might be assigned a cut-off of 0.10, while other items might have a cut-off of 0.25.

g. Discrimination indices will be classified as either positive (+), negative (-), or nondiscriminating (0). By positive and negative indices we mean indices that discriminate significantly (as some appropriate α level) in the positive and negative directions, respectively. The discrimination index used should, of course, be appropriate for the data in question.

h. Before instruction we can obtain three types of data for each objective that has a pretest item:

(1) the Theoretical Error Rate (TER), which is the expected proportion of students getting a pretest item incorrect simply on the basis of random guessing; i.e., if K is the number of possible answers to an item, then

$$TER = \frac{K - 1}{K} \qquad (5)$$

For example, if an item has five alternatives, we would expect 80 percent of the students to get the item incorrect simply by guessing, without any knowledge of the objective tested by the item;[2]

(2) the Base Error Rate (BER), which is the observed proportion of students getting a pretest item incorrect; and

(3) the Base Discrimination Index (BDI), which is the discrimination index for a pretest item. (We will use total score on the pretest as the criterion variable for BDI.)

i. After instruction we can obtain two types of data for each objective that has a posttest item: (a) the Posttest Error Rate (PER) and (b) the Posttest Discrimination Index (PDI). (Total score on the posttest will be used as the criterion variable for PDI.)

j. Immediately following the instruction for any objective we can obtain the Instructional Error Rate (IER), which is the error rate on a terminal test item for a given objective.[3] Note that IER refers to the error rate on a terminal item, not the error rate on other questions associated with teaching the given objective. We will not consider Instructional Discrimination Index since, in our opinion, it does not seem to be very useful for making decisions beyond those that can be made with the other types of data.

k. In subsequent sections we will analyze the decisions that can be made on the basis of: (a) pretest data, alone; (b) posttest data, alone; (c) pretest and posttest data; and (d) pretest, posttest, and terminal item data. In this way, the cumulative contribution of these types of data to the decision process should be evident. Then we will discuss the decisions that can be made based upon arithmetic differences between various error rates. Subsequently, two sets of data will be discussed: the first will be used to empirically demonstrate the contribution of the various types of data to the decision process and the second will be used to present an efficient application of the decision process.

l. For each decision rule presented we will give our reasons for specifying whether test items or instruction relevant to a given objective should be revised (R), questioned (?), or not revised (NR). These decisions should not, however, be interpreted too strictly; the evaluator will still have to use some degree of subjective judgment. For example, when we say, in subsequent discussions, that an item should be revised (R), we mean that our best guess on the basis of the data is that the item should be revised, but the evaluator must make the final decision. Also, when we say that an item (or instruction) is questionable (?), we mean that the data are not sufficient to make a definite judgment about whether or not the item (or instruction) should be revised.

m. Since we are assuming that all items testing a given objective are identical or "corresponding", a decision about item revision applies equally to all items testing the objective in question. Thus, when we say that an item should be revised, we mean that our best guess is that all items testing the given objective should be revised. On the other hand, when we say that instruction should be revised, we mean that that part of the instructional system that attempts to teach the given objective should be revised.

n. One additional consideration deserves mention. Ideally, one would validate his test items prior to using them in an instructional system; however, this is often not feasible, especially in the criterion-referenced testing situation that is an integral part of many instructional systems. Therefore, in most cases, the activity of formative evaluation must take into account the possible invalidity of both test items and instruction. For this reason, most of the decision rules that will be presented are based upon the assumption that we have no a priori reason to believe that test items are more valid than instruction or vice-versa.

<u>Pretest Data</u>

a. Prior to instruction we can collect three sets of data: Theoretical Error Rate (TER), Base Error Rate (BER), and Base Discrimination Index (BDI). Given these three sets of data, various reasonable rules can be formulated for making decisions about whether or not to revise test items. It is not likely that only pretest data would be used to make decisions about items, yet it is useful to consider the types of decisions that are appropriate on the basis of such data.

(1) <u>Rule 1.</u> If TER and BER are both the same (i.e., H, H or L, L), then no necessity for revision is indicated. In this case, the observed error rate (BER) without benefit of instruction is approximately the same as the expected error rate (TER).

(2) <u>Rule 2.</u> If TER is low (L) and BER is high (H), then no revision is indicated. This anomalous case could arise if the particular objective for the item involved concepts that are typically misunderstood. For example, many students (in the authors' opinion) believe that "inflammable" and "flammable" have different meanings. If an item were constructed testing whether or not "inflammable" and "flammable" have the same meaning, and if this item were given prior to instruction, it is quite possible that more students would get the item incorrect than we would expect on the basis of the theoretical error rate (TER). In this case, there is no reason to revise the item; rather, we expect that the instruction will correct the students' misconception. This should be validated within the training situation.

(3) <u>Rule 3.</u> If TER is high (H), and BER is low (L), then the item will probably need to be revised. In this case, students, without benefit of instruction, are performing considerably better than expected. It appears that the item itself may

be teaching or that one or more distractors are so easy that many students can pick the correct answer largely by a process of elimination. Another possible explanation is that the readability level of certain distractors is so high that the test-wise student correctly guesses that they are incorrect. (See Klare, 1963, for techniques to determine readability level.) In any case, the item seems to need revision.[4]

(4) Rule 4. If an item is negatively discriminating before instruction, then the item is questionable in that it may need revision. If, however, the item is positively discriminating or nondiscriminating, then no revision is indicated. A negatively discriminating item is questionable since it indicates that the poorer students (on the basis of total test score) are out-performing the better students; however, a situation similar to that indicated in Rule 2 could be the cause of the negative discrimination index. A positively discriminating item is quite possible and reasonable prior to instruction simply because some good students are usually expected to perform better than chance on a pretest. A nondiscriminating item is the best of all possibilities.

(5) Rule 5. If an item is positively or negatively discriminating before instruction, then the prerequisites for the objective tested by the item should be checked. Clearly, whenever an item is discriminating (either positively or negatively) one group (upper or lower) is outperforming the other group (lower or upper). In such a case, it seems reasonable to check whether or not the group with the higher error rate does, in fact, possess the prerequisites necessary to achieve the given objective.

b. These rules, as well as all other rules that will be discussed, are given in abbreviated form in Table 1.

TABLE 1. Rules for Decision-Making

	Error Rates						Decision[a]		
Rule No.	TER	BER	BDI	IER	PER	PDI	Item	Instruction	Prerequisites
1	H	H					NR		
	L	L					NR		
2	L	H					NR		
3	H	L					R		
4			-				?		
5			+						E
			-						E
6					L	0	NR	NR	
7					L	+	?	?	
					L	-	?	?	
8					H	-	R	R	
9					H	+	?	R	
					H	0	?	R	
10						+			E
						-			E
11			-			-	R		

TABLE 1. Rules for Decision-Making (Cont)

	Error Rates						Decision[a]		
Rule No.	TER	BER	BDI	IER	PER	PDI	Item	Instruction	Prerequisites
12				L	L			NR	
13				L	H			R	
14				H	L			?	
15				H	H			R	
16	DER*[b]						R		
	DER(NS)[c]						NR		
17					$RER > c_1$			R	
					$0 \leq RER \leq c_1$			NR	
18					$RER < -c_2$			?	
					$-c_2 \leq RER \leq 0$			NR	
19		$PMPG < c_3$						R	
		$PMPG \geq c_3$						NR	

[a]"NR" means no revision required.

"R" means revision is required.

"?" means the data are not sufficient to make a sound judgment about whether or not revision is required.

"E" means the prerequisites for the objective should be examined.

[b] DER is significantly greater than zero at the .05 level for a one-tailed test of significance.

[c] DER is not significantly greater than zero at the .05 level for a one-tailed test of significance.

Note.--c_1, c_2, c_3 are cut-offs chosen by the evaluator.

Posttest Data

As a result of administering a posttest two types of data can be collected: the Posttest Error Rate (PER) and the Posttest Discrimination Index (PDI). Since these data are collected after instruction, theoretically decisions can be made about both items and instruction; however, it is very difficult to identify items and instruction that should be revised solely on the basis of posttest data. In almost every case, we can say whether or not there is something wrong, but we cannot pinpoint the problems.

a. Rule 6. If PER = L and PDI = 0, then neither the item nor the instruction need to be revised. This is the best possible situation, since the optimal conditions for both error rate and discrimination index are fulfilled; i.e., at the end of instruction we hope that most of the students get the posttest item correct (PER = L), and that the item is nondiscriminating (PER = 0). (Later we will discuss our reasons for preferring nondiscriminating items.)

b. Rule 7. If PER = L and PDI = + or -, then both the item and the instruction are questionable. The fact that PDI is clearly nonzero indicates a possible need for revision.

c. Rule 8. If PER = H and PDI = -, then both the item and instruction should be revised, since PER = H and PDI = - is the worst possible situation that can occur. It is possible that either the item or the instruction is at fault, but not both; however, we assume here that the most universally applicable decision is to check both the item and the instruction to see what revisions are needed.

d. Rule 9. If PER = H and PDI = + or 0, then the instruction should be revised and the item should be questioned. Whenever error rate is high after instruction, something is wrong, but without additional information we do not know whether the fault definitely lies with the item or the instruction. However, the authors believe that evaluators are often more confident about test items than they are about methods or materials for instruction; it is also possible that the test items have been previously validated or partially validated. Therefore, in this case, it seems reasonable to place a less stringent criterion on the item than on the instruction. It should be noted, however, that perceptions can be biased; i.e., the test item could be at fault. It is certainly advisable to analyze the nature of any validation or pre-validation activity for its applicability in the present context since sampling, testing, and teaching conditions can vary considerably.

e. Rule 10. When PDI = + or PDI = -, then the prerequisites for the objective tested by the item should be examined. The reason for this decision is identical to that presented in Rule 5 in the previous section.

Pretest and Posttest Data

a. It is evident from Table 1 that neither the pretest data alone (See Rules 1-5.) nor the posttest data alone (See Rules 6-10.) give the evaluator much indication about which items and/or sections of instruction should be revised. Clearly, more meaningful decisions can be made by combining the two sets of data. When this is done, all of the rules discussed in the last two sections are applicable, with the exception of Rule 5 which is superseded by Rule 10. In addition, one more rule can be specified.

b. Rule 11. If BDI = - and PDI = -, then the item should be revised. Both before and after instruction the item is negatively discriminating, which means that the upper group (based on total test score) has a proportionately higher error rate than the lower group. This clearly is an unfortunate circumstance indicating that the item should be revised.

Pretest, Posttest, and Terminal Item Data

a. Recall that Instructional Error Rate (IER) is the error rate on a terminal item immediately following instruction. If, in addition to pretest and posttest data, we also take into account IER, it is possible to make fairly definite statements about whether or not to revise most segments of instruction that are related to terminal objectives. The addition of IER does not, however, tell us much more about the revision of items than we already know from pretest and posttest data. All of the rules previously specified are applicable except for Rule 5 which is superseded by Rule 10. Also, we can specify four additional rules.

(1) Rule 12. If instructional Error Rate (IER) and Posttest Error Rate (PER) are low, then no revision (NR) of instruction is indicated. Both during instruction and after instruction most of the students seem to achieve the objective (tested by the instructional item and the posttest item); therefore, we have two indications that the instruction is adequate, and no revision is indicated.

(2) Rule 13. If IER = L and PER = H, then the instruction should be revised. During instruction, students seem to achieve the objective, but on the posttest the same students have a higher error rate for the same objective. Thus the data indicate a retention problem, and the instruction should be revised to correct this situation. Perhaps more practice or review is needed. Factors known to affect short-term retention should be considered in making revisions.

(3) Rule 14. If IER = H and PER = L, then the instruction should be questioned. This is probably an unlikely situation that would seldom occur in practice, although it may be explainable in terms of reminiscence (See McGeoch and Irion, 1952; Estes, 1970.) and interference (negative transfer). In any case, the fact that

students experience a high error rate on a terminal test item (frame in CAI) during instruction seems to indicate that something may be wrong with the instruction.[5]

(4) Rule 15. If IER = H and PER = H, then the instruction definitely should be revised. Both during and after instruction students do not seem to achieve the objective under consideration. We, therefore, have two indications of a need for revising the instruction.

b. Note that in the context of Rules 12-15, a posttest item is, in part, a measure of retention. Clearly, the evaluator must temper his decisions about revision with knowledge about the length of time intervening between instruction and testing, and especially about the type of intervening activity. The criticality of forgetting and the processes determining it should be carefully considered. (See Adams, 1967.)

Decisions Based Upon Differences Between Error Rates

a. The utility of most of the foregoing decision rules is dependent upon the evaluator's choice of a cut-off level differentiating high and low error rates. Dichotomizing error rate in this way clearly facilitates the identification of appropriate decision rules, and, in many cases, the simplicity of the technique will probably outweigh any loss of precision. However, we can also specify an additional set of four useful decisions rules that take into account quantitative differences between error rates. Three of these rules increase the power or previous decisions, the other provides essentially new information. We will call these error rates "derived" error rates in order to distinguish them from the "raw" error rates discussed in the previous sections.

b. Let us consider several limits and limitations of the high/low classification procedure for error rates. Suppose that Theoretical Error Rate (TER) and Base Error Rate (BER) for a given objective are both classified as high (H), while Instructional Error Rate (IER) and Posttest Error Rate (PER) are both classified as low (L). Clearly, any actual arithmetic differences between TER and BER, as well as between IER and PER, will not affect the decisions we have thus far proposed. Also, since BER and IER are merely classified as high and low, respectively, we will not have a quantitative measure of how much learning has actually taken place.

Difference Error Rate

a. Rules 1-3 are useful for making decisions based upon categorical differences between BER and TER, but we can make more accurate decisions by actually computing the differences between these error rates.

Let:

$$DER = TER - BER, \qquad (6)$$

where DER stands for "Difference Error Rate". If DER = 0, then the observed error rate (BER) on the pretest item in question is identical to the expected error rate (TER). If DER $<$ 0, then fewer students are getting the item correct than we would expect on the basis of random guessing. Finally, if DER $>$ 0, then more students are getting the item correct than we would expect. As discussed previously, the last possibility is often an unfavorable situation, since it can mean that the item somehow "gives away" the correct answer.

b. We can test the significance of a positive difference between BER and TER by computing

$$Z = \frac{DER - 1/2(N)}{\sqrt{TER(1 - TER)/N}}, \qquad (7)$$

where N is the total number of students in the sample. (See Snedecor & Cochran, 1967, p. 210.)[6] The computer Z value is then compared with the normal curve standard score at an appropriate level of significance for a one-tailed test. (Note that we are interested only in positive values of DER.) We can now specify a more precise rule to replace Rules 1-3.

c. Rule 16. If the value of DER is significantly greater than zero, then the item should be revised. In all other cases no revision is required.

Retention Error Rate

a. Rules 12-15 are useful for making decisions based upon categorical differences between IER and PER, but we can supplement these decisions by calculating the actual difference between IER and PER and comparing this value to some preassigned cut-off. Let:

$$RER = PER - IER,$$

where RER stands for "Retention Error Rate". If RER = 0, then the number of errors on the posttest item and the related terminal item is identical, and no retention problem is evident. If RER $>$ 0, then students make more errors on the posttest item than on the terminal item. The latter situation can be serious if RER is considerably greater than zero; however, it is not clear how to define "considerably greater than zero".

b. We could, of course, statistically test whether or not RER is significantly greater than zero if certain distributional assumptions can be made, but such a test would not, in our opinion, provide a meaningful basis for decision. What is needed is a cut-off above which the amount of forgetting is great enough to justify revision of instruction. Such a cut-off must take into account the criticality of forgetting which in turn is dependent upon many factors including the subject matter of the instructional system and the student population for which the system is being developed. Furthermore, there is no theoretical rationale for specifying the same cut-off for all items. Thus, in our opinion only the evaluator can make an appropriate choice of a useful cut-off.[7] It, therefore, seems reasonable to specify the following rule as a more powerful version of Rule 13.

c. Rule 17. If RER $> c_1$, where c_1 is a cut-off specified by the evaluator, then the instruction should be revised, since the data indicate a retention problem. If $0 \leq$ RER $\leq c_1$, then no revision is required. The cut-off, c_1, need not be the same for all objectives.

d. The one possibility that we did not consider above is RER < 0; i.e., students make fewer errors on the posttest item than on the terminal item. We stated previously, in the discussion of Rule 14 that this is an unlikely occurrence; however, the evaluator may want to specify a cut-off below which he considers this problem to be serious enough to merit a closer examination of the instruction. Again, research findings concerning reminiscence and negative transfer may be useful in guiding revision.

e. Rule 18. If RER $< -c_2$, is a cut-off specified by the evaluator, then the instruction should be questioned. If $-c_2 \leq$ RER < 0, then no revision is required. As before, the cut-off c_2 need not be the same for all objectives. (See footnote 5.)

Percentage of Maximum Possible Gain

a. None of the decisions discussed up to this point has made use of any measure of gain in knowledge relevant to a given objective that results from the instructional system. It is probably true that gain is not as important as final performance on the posttest, in most instructional systems; however, if students experience relatively little gain as a result of experiencing instruction, one can legitimately question the value of the instructional system itself. Thus, measures of gain have long been a subject of considerable interest in the fields of programmed instruction, computer-aided instruction, and multimedia instruction. (See Lumsdaine, 1965.)

b. The simplest measure of gain for an objective is the difference between theoretical error rate (TER) and error rate on the corresponding terminal item (IER); however, a better measure is the difference between error rate on a pretest item (BER) and error rate on the corresponding terminal item (IER).[8] The latter measure would, however, mean that a gain of 0.50 resulting from BER = 1.00 and IER = 0.50 would be indistinguishable from a gain of the same magnitude resulting from BER = 0.50 and IER = 0.00. In the former case, the instructional system has failed to produce 50 percent of the gain in performance that could be achieved, while in the latter case, the instructional system has produced as much gain as possible given the entry level of the students. Thus, in the former case, some revision of the instruction may be desirable, while in the latter case, no revision in the instructional system is required on the basis of these data.

c. The above, rather trivial example, illustrates that simple gain does not provide a very meaningful basis for revising instruction. A better measure is percent of maximum possible gain for an objective, defined as:

$$PMPG = \frac{BER - IER}{BER} \tag{9}$$

In order to make use of this measure the evaluator must specify a cut-off that determines whether or not a given value for PMPG indicates a need for revision.

d. Rule 19. If PMPG $< c_3$, where c_3 is a cut-off specified by the evaluator, then the instruction should be revised. The cut-off c_3 need not be the same for all objectives. If PMPG $\geq c_3$, then no revision is required.

e. The literature contains many in-depth discussions and debates about the problems and pit-falls associated with measures of gain. (See, for example, Cronbach and Furby, 1970; DuBois, 1962; and Harris, 1963.) Most of this literature, however, treats measures of gain in the context of their use in inferential statistics or correlational analysis. While we appreciate the importance of these issues, we hasten to add that measures of gain, merely as descriptive statistics, can provide useful information to evaluators. We believe that the use of PMPG, as data for evaluation purposes, is a case in point.

f. When data of the type discussed in this section are used along with the basic pretest, posttest, and terminal item data, then the appropriate decision rules are: 6-11 and 16-19. If only pretest and posttest data are available, then Rule 16 can be used to replace Rules 1-3.

Two Examples

a. The data reported in Table 2 are based upon the responses of 28 students to a subset of test questions (both completion and multiple-choice varieties) in an interactive CAI program in microeconomics.[9]

TABLE 2. Error Rates and Discrimination Indices for a CAI Program in Microeconomics

Objective	Raw Error Rates and Discrimination Indices							Derived Error Rates	
Number	TER	BER	BDI	IER	PER	PDI	DER	RER	PMPG
1	1.000	.750	.365	.250	.071	.205	.250*	-.179	.667
2	.875	.964	.304	.143	.643	.880**	-.089	.500	.852
3	.750	.786	.055	.107	.106	.205	-.036	-.001	.864
4	.750	.714	.650**	.214	.036	.141	.036	-.178	.700
5	.500	.604	.786**	.321	.000	.000	-.104	-.321	.469
6	.667	.714	.475*	.107	.179	.015	-.047	.072	.850
7	.750	.893	.548*	.321	.393	.510	-.143	.072	.641
8	1.000	1.000	.000	.286	.607	.535	.000	.321	.741
9	.500	.857	-.032	.071	.179	.309	-.357	.108	.917
10	.500	.500	.000	.000	.214	.309	.000	.214	1.000
11	1.000	.964	.304	.321	.143	.015	.036*	-.178	.667
12	1.000	.929	.132	.286	.429	.459	.071*	.143	.692
13	.500	.821	.737**	.214	.214	.357	-.321	.000	.739
14	1.000	.857	.420	.607	.464	.630*	.143*	-.143	.292
15	.500	.679	.580**	.143	.214	.357	-.179	.071	.789
16	1.000	1.000	.000	.143	.500	.535	.000	.357	.857
17	1.000	1.000	.000	.393	.964	.394	.000	.571	.607
13	.875	.964	.304	.679	.786	.397	-.089	.107	.296

* $p < .05$ ** $p < .01$

b. The discrimination index used for both BDI and PDI is the phi-coefficient. In the case of BDI, all students with scores of four or more items correct on the pretest were classified into the upper criterion group, and all other students were classified into the lower criterion group. In the case of PDI, all students with scores of 15 or more items correct on the posttest were classified into the upper group, and all students with scores of 12 or fewer items correct were classified into the lower group. Both BDI and PDI were tested using a correction for discontinuity (See Edwards, 1967, p. 333.) and two-tailed probability levels.

c. The categorical error rates and discrimination indices given in Table 3 are based upon the cut-off values indicated in the footnotes to that table. The cut-offs used were selected primarily for illustrative purposes, and are not necessarily intended to be optimal cut-offs from a theoretical standpoint. Note that, while not necessary, the cut-offs used are the same for all items. (The reader may find it instructive to reanalyze the data with different cut-offs.)

TABLE 3. Categorical Error Rates and Discrimination Indices for a CAI Program in Microeconomics

	Raw Error Rates and Discrimination Indices[a]						Derived Error Rates		
Objective Number	TER	BER	BDI	IER	PER	PDI	DER[b]	RER[c]	PMPG[d]
1	H	H	0	L	L	0	*	-	-
2	H	H	0	L	H	+	-	GT	-
3	H	H	0	L	L	0	-	-	-
4	H	H	+	L	L	0	-	-	-
5	H	H	+	H	L	0	-	LT	LT
6	H	H	+	L	L	0	-	-	-
7	H	H	+	H	H	0	-	-	-
8	H	H	0	L	H	0	-	GT	-
9	H	H	0	L	L	0	-	-	-
10	H	H	0	L	L	0	-	GT	-
11	H	H	0	H	L	0	*	-	-
12	H	H	0	L	H	0	*	-	-
13	H	H	+	L	L	0	-	-	-
14	H	H	0	H	H	+	*	-	LT
15	H	H	+	L	L	0	-	-	-
16	H	H	0	L	H	0	-	GT	-
17	H	H	0	H	H	0	-	GT	-
18	H	H	0	H	H	0	-	-	LT

TABLE 4. Revision Decisions by Objective for a CAI Program in Microeconomics

Objective	Decisions Using All Data[a]			Decisions Using Raw Error Rates and Discrimination Indices[a]			Decisions Using Only Pretest and Posttest Data[a,b]		
Number	Item	Instruction	Prerequisites	Item	Instruction	Prerequisites	Item	Instruction	Prerequisites
1	R(16)	NR(6)		NR(6)	NR(12)		NR(6)	NR(6)	
2	?(9)	R(9, 17)	E(10)	?(9)	R(9, 13)	E(10)	?(9)	R(9)	E(10)
3	NR(6)	NR(6)		NR(6)	NR(12)		NR(6)	NR(6)	
4	NR(6)	NR(6)		NR(6)	NR(12)		NR(6)	NR(6)	
5	NR(6)	R(19)		NR(6)	?(14)		NR(6)	NR(6)	
6	NR(6)	NR(6)		NR(6)	NR(12)		NR(6)	NR(6)	
7	?(9)	R(9)		?(9)	R(9, 15)		?(9)	R(9)	
8	?(9)	R(9, 17)		?(9)	R(9, 13)		?(9)	R(9)	
9	NR(6)	NR(6)		NR(6)	NR(12)		NR(6)	NR(6)	
10	NR(6)	R(17)		NR(6)	NR(12)		NR(6)	NR(6)	
11	R(16)	NR(6)		NR(6)	?(14)		NR(6)	NR(6)	
12	R(16)	R(9)		?(9)	R(9, 13)		?(9)	R(9)	
13	NR(6)	NR(6)		NR(6)	NR(12)		NR(6)	NR(6)	
14	R(16)	R(9, 19)	E(10)	?(9)	R(9, 15)	E(10)	?(9)	R(9)	E(10)
15	NR(6)	NR(6)		NR(6)	NR(12)		NR(6)	NR(6)	

TABLE 4. Revision Decisions by Objective for a CAI Program in Microeconomics (Cont)

Objective	Decisions Using All Data[a]		Decisions Using Raw Error Rates and Discrimination Indices[a]		Decisions Using Only Pretest and Posttest Data[a,b]	
Number	Item	Instruction Prerequisites	Item	Instruction Prerequisites	Item	Instruction Prerequisites
16	?(9)	R(9, 17)	?(9)	R(9, 13)	?(9)	R(9)
17	?(9)	R(9, 17)	?(9)	R(9, 15)	?(9)	R(9)
18	?(9)	R(9, 19)	?(9)	R(9, 15)	?(9)	R(9)

[a]"NR" means no revision is required.

"R" means revision is required.

"?" means the data are not sufficient to make a sound judgment about whether or not revision is required.

"E" means the prerequisites for the objective should be examined.

Numbers in parentheses are rule numbers.

[b]Difference Error Rate, DER, is not used here as a basis for making decisions.

d. Table 4 lists the decisions that result from applying the various decision rules to three different subsets of the data reported in Table 3. When two rules indicate a need for revision, both are given; in most other cases, only one rule is applicable. Occasions do arise, however, when two or more different decisions are applicable to the same item or segment of instruction. For example, objective number five has IER = H, PER = L, and PDI = 0. According to Rule 6 the instruction does not need revisions, but Rule 14 indicates that the instruction is questionable. We have chosen to resolve such conflicts by selecting the decision that has the most serious implications for revision; i.e., "questionable" (?) has more serious implications for revision than "do not revise" (NR), and "revise" (R) has more serious implications for revision than either "questionable" (?) or "do not revise" (NR). Thus, for objective number five we have labelled the instruction "questionable" in the second set of decisions.

e. In Table 4 the first set of decisions uses more data than the second which, in turn, uses more data than the third. One possible effect of decreasing the amount of data used is illustrated by the decisions with regard to instruction for objective number five. Using all of the data for objective five in Table 4, Rule 19 indicates that the instruction should be revised. When, however, derived error rates are eliminated, Rule 19 becomes inapplicable, and Rule 14 indicates that the instruction should be examined, but not necessarily revised. Finally, when both derived error rates and IER are eliminated, both Rules 19 and 14 become inapplicable, and Rule 6 indicates that no revision is required. This situation is an empirical demonstration of the desirability of obtaining as much data as possible in order to strengthen decisions about the adequacy of instruction.

f. This statement does not, however, imply that an increase in the amount of available data will necessarily increase the number of decisions involving the revision (R) of items or instruction. Consider, for example, the decisions involving instruction, given in Table 4, for objective number 11. Using only pretest and posttest data, no revision is required according to Rule 6. When IER is included as data for decision making, the second set of decisions indicate that the instruction is questionable according to Rule 14. When, however, all available data are used (i.e., pretest and posttest data, IER, and the derived error rates), we again arrive at the decision "no revision" according to Rules 6 and 18.[10] Clearly, in the case of objective 11, an increase in the amount of available data ultimately confirms our initial judgment that no revision of instruction is required.

g. For this particular instructional system, Table 4 indicates that the availability of derived error rates increases the number of decisions that involve revision of items and instruction. Furthermore, in general, revision is most often necessitated by relatively poor performance on the posttest (note the many times Rules 8 and 9 are employed) and relatively poor retention (note the many times Rules 13 and 17 are employed). Also, the instruction seems to be in more need of revision than the test items. These general observations do, in fact, coincide with the predictions of the person responsible for developing this particular instructional program.[11]

h. The following example empirically illustrates the contribution of various types of data to the decision process; however, there are clearly more efficient ways to evaluate instruction, in the formative sense of the term, using the rationale, types of data, and decision rules previously presented. Consider, for example, the data presented in Table 5.

i. These data reflect the performance of 39 students on test questions related to 12 terminal objectives selected from a multimedia economics course during its field-testing phase.[12] The first 11 objectives were tested by a pretest, terminal, and posttest item; the last objective was tested by a pretest and posttest item, but not a terminal item.

TABLE 5. Data and Decisions for Selected Objectives from a Multimedia Economics Course

	Data						Decision		
Objective Number	DER	BDI	PMPG	PER	PDI	RER	Item	Instruction	Prerequisites
1	.135*	.287	.958	.051	.095	.025	R(16)		
2	-.250	.000	1.000	.256	.167	.256		R(17)	
3	.391**	.037	.928	.000	.000	-.026	R(16)		
4	-.019	.389*	1.000	.410	.143	.410	?(9)	R(9, 17)	E(5)
5	.263**	.343	1.000	.026	-.056	.026	R(16)		
6	-.071	.583**	.812	.026	.048	-.128			E(5)
7	-.096	.500**	1.000	.026	.048	.026			E(5)
8	.083	.602**	.654	.000	.000	-.231		R(19)	E(5)
9	-.224	-.037	.658	.590	.373	.257	?(9)	R(9, 17, 19)	
10	.391**	.278	1.000	.000	.000	.000	R(16)		
11	-.224	.083	.631	.513	.024	.154	?(9)	R(9, 19)	
12	-.122	.296	--	.359	.357	--	?(9)	R(9)	

* $p < .05$

** $p < .01$

j. The reader can easily verify that the six types of data reported in Table 5 are a sufficient set in terms of the Rules listed in Table 1 (recall that Rules 16-18 can be used to replace Rules 1-3 and 12-15). For the decisions reported in Table 5, the high/low cut-off value for PER is 0.30, c_1 is 0.20, c_2 is 0.25, and c_3 is 0.70. The B index (See Brennan, in press.) was used for both BDI and PDI.

k. Using the decisions indicated in Table 5 we referred back to the instructional material in search of explanations for the indicated "problems". For objectives 1, 3, 5, and 10 we could eliminate at least two distractors in the associated pretest items without reading the subsequent instructional material. The pretest items for objectives 6 and 7 involved the interpretation of very complex graphs; however, this activity seems to be taught within the course, as evidenced by posttest performance for these objectives. For objectives 2 and 9, which involve mathematical or graphical skills, the retention problem appears to be the primary difficulty. The terminal and posttest items for objective 4 seem to be different enough to warrant revision of at least one of them. Objective 8 seems to be achieved after the terminal item for this objective is presented. Objectives 11 and 12 seem to require further instruction.

l. The objectives discussed above are only a very small fraction of the total number of objectives covered in this course; in the total course 97 percent of the students achieved 80 or more percent of the objectives. Nevertheless, it appears that the procedure we have outlined can serve a useful function for formative evaluation.

Discussion

a. It is certainly reasonable to expect that some readers may feel that certain decisions we have proposed are not appropriate for their particular programs, or that other decision rules should be added. We have tried to specify those decisions that we feel are the most universally applicable; however, even more important than the actual decision rules presented is the method used to arrive at decisions about test items and instruction. This method appears to be generalizable to a wide variety of instructional situations, and it seems to maximize the use made of instructionally relevant data heretofore used separately rather than as elements of a coherent system of analysis for decision.

b. In this section we will discuss various factors that have applicability to the rules we have presented and the decision process we have proposed.

Instructional Systems and Criterion-Referenced Testing

a. One might define an instructional system in general as a replicable method of instruction providing feedback that can be used for revision purposes. Replicability is always a matter of degree, but particular approaches appear to differ on the average in the respect; e.g., instruction provided by teachers is less replicable than that provided by a computer. Also, in addition to replicability, instructional systems are usually characterized by a close correspondence between test items and behavioral objectives, i.e., test items are criterion-referenced. In addition, it is usually expected that "most" of the students will get "most" of the terminal and posttest items correct.

b. Brennan (1970) and Popham & Husek (1969) have examined some aspects of the applicability of classical test theory to the analysis of criterion-referenced tests. Perhaps the most important implication of these analyses is that the classical normality assumptions concerning errors of measurement do not seem to be appropriate in many criterion-referenced testing situations; the errors of measurement seem to be better characterized by binomial error models. (See Lord & Novick, 1968, Chapter 23.) This means that many of the statistics used in classical test theory are not applicable in the criterion-referenced testing situation. For example, the biserial discrimination index is not appropriate for criterion-referenced test data, since total scores on the test are not necessarily normally distributed; a similar comment can be made about the tetrachoric discrimination index.

c. Another characteristic of a good instructional system is that all students who possess the necessary prerequisites and who receive instruction should achieve criterion performance on the posttest. (See Stolurow & Davis, 1965.) Ideally, in fact, we may want all students to achieve all objectives. In such a situation all items would be nondiscriminating (assuming, of course, that total test score is the criterion used for judging discriminability). This line of reasoning indicates why we have specified that nondiscriminating items do not indicate a need for revision. Conversely, items that are significantly discriminating (especially negatively discriminating items) indicate a possible need for revision since the instructional system is performing worse for one group of students than for another group.

Corresponding Items

a. When discussing the context of the rationale that has been presented, we assumed that for each objective there exists a pretest, posttest, and terminal test item; furthermore, we assumed that the items testing a given objective are, in some sense, "corresponding", "equivalent", or "parallel".

b. The terms "equivalent" and "parallel" are, in the classical sense, usually applied to tests. A set of k tests are said to be "parallel" or "equivalent" if they have equal means, equal variances, and equal intercorrelations. (See Gulliksen, 1950, p. 173.) This does not mean, however, that there is necessarily any strict correspondence among items in the k tests. Thus, in the rationale that we have proposed, and in criterion-referenced testing in general, the classical concept of parallel tests is clearly not sufficient, since we are very concerned about the performance of students on individual items, not just entire tests. Let us, therefore, reserve the terms "parallel" and "equivalent" for entire tests, and examine the analogous issue of "corresponding" items.

c. We can define "corresponding" items, in general, as items that measure the same thing. Clearly, then, one requirement of corresponding items is that, in the judgment of specialists the items measure the same behavioral objective. Furthermore, just as we have a statistical criterion for parallel tests, it seems reasonable to propose a similar statistical criterion for corresponding items. Thus, we might propose that corresponding items have equal means, equal variances, and equal intercorrelations. Since we are assuming that items are scored dichotomously, the mean of item i is simply the proportion of correct responses (p_i) and the correlation between any two corresponding items is the phi correlation (r_ϕ).

d. Now, suppose we give a set of k tests to N students in order to determine whether or not the tests are parallel; i.e., whether or not the set of k means, k variances, and k(k - 1)/2 intercorrelations are equal except for sampling differences. Wilks (1946) provides a statistical test to answer this question.

e. Unfortunately, however, Wilks' test is not applicable for judging the equality of a set of means, variances, and intercorrelations for k dichotomously scored criterion-referenced items. Wilks' test assumes a normal multivariate population distribution, and, as we have stated previously, the assumption of normality is probably inappropriate in most criterion-referenced testing situations.

f. As far as we know, there is no currently available method for simultaneously testing the equality of means, variances, and correlations among dichotomously scored items that are not necessarily normally distributed. We can, however, approach a solution to the problem by applying what is usually called Cochran's Q Test (See Siegel, 1956, pp. 161-166.), which is a test for the equality of means, or proportions (p_i), among dichotomized variable (in this case, test items).

g. Since the variance of a dichotomous variable scored zero or one is completely determined by the mean (or proportion of successes), it is clear that if the means of k items are equal, then the variances will also be equal. However, even if the means and variances of k items are equal (except for sampling differences), this does not necessarily mean that the intercorrelations are equal. The authors have no knowledge of any currently available method to test the equivalence of intercorrelations (phi-coefficients) among dichotomously scored items which may not be distributed normally in the population.

h. Besides the problem of nonnormally distributed variables there is another problem in testing the equivalency of intercorrelations (phi-coefficients) that may not be immediately evident. Suppose we have three items (i.e., k = 3). In order to test whether or not the intercorrelations among the items are the same, we must take into account three different phi-coefficients: (a) r_ϕ between item one and item two, (b) r_ϕ between item one and item three, and (c) r_ϕ between item two and item three. Now, it is clear that (a) and (b) are correlated because both phi-coefficients are based on the same data for item one; (a) and (c) are also correlated since they are based on the data for item two; and finally, (b) and (c) are correlated because they are based on the same data for item three. Since the three r_ϕ's are clearly correlated, we cannot apply any of the well-known chi-square tests that are currently available for use with contingency tables. In the absence of a test of significance for examining the equivalence of intercorrelations (phi-coefficients) among k items, the evaluator will probably have to use his best judgment about whether or not the phi-coefficients are "approximately" equal.

i. In summary, we have defined corresponding items as items that (a) measure the same behavioral objective, (b) have the same means, (c) have the same variances, and (d) have the same intercorrelations. We have recommended Cochran's Q Test as a method for testing (b) and (c). The lack of an available statistical test for (d) may not be too serious a limitation; certainly, if conditions (a), (b), and (c) are fulfilled and the intercorrelations among the items are approximately equal, it is reasonable to assume that the items are "corresponding".

Comments on Data for Decision Making

a. For purposes of simplicity, the decision rules we have specified are based upon data from one pretest item, one terminal item, and one posttest item for each objective. There may, of course, be more than one pretest, terminal, and/or posttest item for any given objective. Such additional data can be taken into account in various ways. For example, one might merely combine the data from all the pretest (posttest or terminal) items relevant to a given objective in order to calculate the appropriate error rate. Alternatively, assuming, for example, that three posttest items test the same terminal objective, one might specify that if a student answers two of the three items correctly, then he has achieved the objective. Other alternatives are also possible; however, a multiplicity of pretest, posttest, or terminal items relevant to a given objective can complicate the interpretation of which item, if any, requires revision.

b. We have also assumed that every student answers every item. There are several formulas available (See Guilford, 1954, pp. 418-424.) that can be used to calculate error rates with missing data. Such formulas can be used instead of Equation 2. A large amount of missing data can, however, present serious problems, especially if the sample size is small.

c. There are many discrimination indices available in the literature (See Guilford, 1954, pp. 424-440.) than could be used to calculate BDI and PDI. In our opinion, however, the phi-coefficient and the B index (See Brennan 1970, 1972.) are the best indices to use with criterion-referenced tests, since they make only weak distributional assumptions, and they allow the evaluator to specify virtually any cutoff between upper and lower groups. In addition, the index B has a very useful interpretation in terms of the number of discriminations made by an item.

d. One further comment seems appropriate. Stolurow and Frincke (1966) have noted that there is a danger of rejecting good items (or good instruction) when the sample size is relatively small, say N = 15 or 20. In their study, Stolurow and Frincke were concerned about error rates only. Since, in this paper we examine both error rates and discrimination indices, it is certainly desirable that the sample size be adequate for most purposes. The technique we have proposed can be used with smaller sample sizes; however, the certainty with which decisions can be made is thereby reduced.

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FOOTNOTES

[1] Much of the research reported herein was performed pursuant to contracts with the Unived States Naval Academy, Contract No. N00161-70-C-0119, and the Office of Naval Research, Contract No. N00014-67-A-0298-0032.

[2] Items that have a virtual infinitude of possible answers have TER = 1.00; however, the evaluator should be careful not to assume that every free-response or open ended test item has TER = 1.00. Very often such items are so worded that only two or three answers are really possible, in which case TER = 0.50 or TER = 0.67.

[3] Terminal Error Rate would be a more descriptive phrase than Instructional Error Rate; however, we have chosen the latter to avoid the ambiguity involved in having TER stand for both Terminal Error Rate and Theoretical Error Rate.

[4] It is also possible that the item has neither of these faults and the objective, while being easy for most of the students, is considered to be an integral part of the total set of objectives. In this case, the item would not be revised. A similar statement can be made for Rule 16 which will be discussed later.

[5] It is also possible that the terminal item (frame) and the posttest item are not measuring the same content at the same level of difficulty, even though this is an assumption underlying all the decision rules presented here. Also, if students receive confirmation on terminal items within the instructional system, then one could argue that the occurrence of IER = H and PER = L does not indicate any need for revision.

[6] The term - 1/(2N) in Equation 7 is a correction for discontinuity and, as such, can be dropped if the sample size is large. Note that when TER = 1.00 Z is undefined; in this case any value of DER > 0 can be considered significant.

[7] Ideally, in order to choose cut-offs for RER parametric data are needed from a variety of situations to determine the mean and standard deviation of retention scores in relation to the investment in learning. One interim possibility is to use the principle of homogeneity in relation to comparable data within a program. The grossly deviant retention scores would reveal the items in greatest need of revision. For example, the cut-off could be the n most extreme items where n is specified by using a percentage (e.g., 5 or 10 percent) of the total number of items.

[8] One could make a case for using error rate on the posttest item (PER) rather than error rate on the terminal item; then, however, PER - BER would involve a confounding of gain with retention, as we are using the terms in this paper.

[9] We are grateful to Mr. Eugene Millstein for developing the instructional program and collecting the data pursuant to a contract with the Office of Naval Research, ONR Contract No. N00014-67-A-0298-0003 conducted at the Harvard Computer-Aided Instruction Laboratory. Our analysis of the data should not, however, be interpreted as an evaluation of the program. (See Millstein, 1971.)

[10] Recall that when derived error rates are available, Rules 16-19 replace Rules 1-3 and 12-15, since the former rules are more exact statements of the latter rules. More specifically, Rule 18, in effect, replaces Rule 14. For objective number 11, application of Rule 18 indicates no need for revision, which overrides the decision made on the basis of Rule 14.

The reader will note that, in Table 4, if two or more rules indicate "no revision (NR)", we have identified only that rule which we believe is most important. There seems to be no particular advantage in identifying all the possible reasons for doing nothing!

[11] This program is being used primarily as a vehicle for testing a psychological theory of sequencing instruction. As such, the program has been purposely written to discriminate among students who have experienced different instructional sequences; the program is not meant to teach microeconomics to all students in the most effective manner.

[12] We are grateful to Sterling Institute of Washington, D. C., the developer of this course, for making these data available to us. However, we wish to emphasize that the data reported and all explanations of such data are incomplete and are used here for illustrative purposes only; in no way should our analysis of these data be construed as an evaluation of their course.

[a] The cut-off value for TER, BER, IER and PER is 0.30.

[b] "-" indicates that DER is not significantly greater than zero at the .05 level for a one-tailed test of significance.

[c] "GT" indicates that RER is "greater than" 0.20.

"LT" indicates that RER is "less than" -0.30.

"-" indicates that $-0.30 \leq RER \leq 0.20$.

[d] "LT" indicates that PMPG is "less than" 0.60.

"-" indicates that PMPG is greater than or equal to 0.60.

* $p < .05$

Appendix

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*Dr. Ward Deutschman attended on-site meeting in place of Dr. Alexander Schure.