Research Report 1470

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Model Training Program for Reserve Component Units: Final Report

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U. S. Army

Research Institute for the Behavioral and Social Sciences

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Addition of new, sophisticated systems to the Army inventory presents special training problems to Reserve Component (RC) maintenance units. Upon mobilization, these units support active units using the new systems, but the RC soldiers have limited training time and little or no access to the new equipment or knowledgeable instructors. The Model Training Program for Reserve Component units investigated the use of computer-based training (CBT) with interactive videodisc to deliver training to RC units. CBT courses were developed for four Military Occupational Specialties responsible for the M1 Abrams tank. The training was fielded for trials for 1 year at three RC units, and effectiveness of the training was evaluated with hands-on and written pre- and posttests. In addition, a survey of over 200 developers of CBT was conducted to investigate the problems of CBT development projects. Recommendations were made for analyzing and procuring CBT projects, estimating costs, enhancing production techniques, and fielding the computer-based training at Reserve units.

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FOREWORD

The introduction of new equipment into the Army inventory poses special challenges for reserve component (RC) units. RC maintenance units frequently have mobilization missions to maintain high-technology weapon systems to which they have little access for training. This report summarizes a computer-based training (CBT) program, the Model Training Program for Reserve Component units (MTP-RC), designed specifically to meet RC training needs. The MTP-RC program used innovative CBT design techniques to develop courseware for training RC soldiers to troubleshoot and maintain M1 tanks. Also included is a summary of the MTP-RC survey on industry-wide CBT development costs and times.

The MTP-RC was a joint research and development project of the U.S. Army Research Institute and TRADOC's Training Technology Agency. The program was directed by the ARI Fort Knox Field Unit as part of a memorandum of understanding dated April 1983 with Training and Doctrine Command (TRADOC), U.S. Army Forces Command (FORSCOM), and the U.S. Army Research Institute (ARI). These final results were presented to the project sponsors, TRADOC, FORSCOM, and the Armor and Ordnance schools in October 1987. Plans are being made to convert the Army-wide distribution and to use the validated MTP-RC instructional approach in the development of CBT for other systems.

EDGAR M. JOHNSON
Technical Director

MODEL TRAINING PROGRAM FOR RESERVE COMPONENT UNITS: FINAL REPORT

EXECUTIVE SUMMARY

Requirement:

The introduction of new equipment into the Army inventory poses special problems for training in the Reserve Component (RC). Soldiers in RC maintenance units must be ready to support the equipment in times of mobilization, but they have limited time for training and often have little or no hands-on experience with the new equipment during their weekend drills or annual training.

Computer-based training (CBT) with interactive videodisc technology can deliver training with realistic video images, computer-generated graphics, and part-task simulations. This medium has the potential to train and sustain skills on new equipment, thereby reducing the time needed for training after mobilization. The Model Training Program for Reserve Components Units (MTP-RC) was conceived by the U.S. Army Research Institute and the Training and Doctrine Command's Training Technology Agency to evaluate the effectiveness and difficulties of developing and delivering CBT for RC units.

Procedure:

Computer-based training material ("courseware") was developed for four Military Occupational Specialties responsible for troubleshooting and maintenance on the M1 Abrams tank, a weapon system that had been fielded at only one RC unit at the time of the program. The courseware was fielded at three RC units for 1-year trials, during which time soldiers took the M1 training on the computer system. Hands-on and written pre- and posttests were conducted to evaluate the training and transfer effects of the training. The difficulties of determining courseware procurements, estimating development costs, developing large amounts of courseware, and fielding the courseware at RC units were also investigated. A survey of over 200 developers of CBT was conducted to make recommendations about analyzing and costing courseware projects.

Findings:

The training and transfer evaluation showed that computer-based training can be effective in training troubleshooting and maintenance skills in RC units with little access to real equipment, limited expertise on the equipment, and limited time for training.

The experiences of the MTP-RC project and those reported in the survey of CBT developers suggested some solutions to the difficulties encountered in producing and fielding the courseware.

- Statements of work for courseware development projects require more detailed descriptions of soldier performance objectives and desired training features than do statements for traditional training.

- There are no widely accepted measures to use in specifying the quantity or quality of courseware to be developed or delivered. Phased procurements, in which developers first conduct a thorough training analysis and then attempt to define the scope and nature of the courseware, should be investigated.

- For developing large quantities of CBT courseware, enhancements to the Systems Approach to Training can result in higher quality of courseware and increased production efficiency.

RC units are already faced with a heavy schedule of skill training and sustainment. For CBT to be successfully implemented in RC units, the program must have Command support, training and support for computer operators, and an environment suitable for housing the computer.

Utilization of Findings:

The results of this project can provide guidance for analyzing, costing, developing, and fielding computer-based training in the Reserve Component and the Regular Army. Consideration of the recommendations made in this report can help enhance some of the potential and avoid some of the problems inherent in CBT.

MODEL TRAINING PROGRAM FOR RESERVE COMPONENT UNITS: FINAL REPORT

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MODEL TRAINING PROGRAM FOR RESERVE COMPONENT UNITS: FINAL REPORT

INTRODUCTION

This Research and Development Program Evaluated the Use of Computer-Based Training for Reserve Component Units.

The Model Training Program for Reserve Component units (MTP-RC) program was a research and development program sponsored by the Army Research Institute (ARI) and Training and Doctrine Command's (TRADOC) Training Technology Agency to evaluate computer-based training (CBT) as a means of delivering training to Reserve Component (RC) soldiers. The purposes of this report are to describe MTP-RC, summarize previous reports on the program, and describe the lessons learned about the development and application of computer-based training for training in the RC environment.

The target audience for the training developed under this program was Reserve Component soldiers with responsibility for troubleshooting and maintenance of the M1 Abrams tank. The program is a response to the problem that RC soldiers have limited opportunity for training and sustaining skills on new equipment such as the M1. The training was developed for soldiers in four specific Military Occupational Specialities (MOSs):

45E M1 *Turret Mechanic*
45K Turret Repairman
63E M1 Automotive Mechanic
63H Automotive Repairman.

The syllabus developed for this program included five courses. The first course was a general, introductory course on the M1 for all four MOSs. It included tank familiarization, safety, technical manuals (TMs), and M1 Test, Measurement, and Diagnostic Equipment (TMDE). The other four courses were specific to critical tasks of each of the four MOSs. The tasks emphasized were electronic troubleshooting and mechanical maintenance of the systems on the tank.

The potential value of using CBT to deliver training to the Reserve Component was emphasized by the fact that, although all of these soldiers would have responsibilities for support of M1 battalions upon mobilization, most of them had little or no training or hands-on experience on the M1 tank. In addition, they have little opportunity to work on the tanks during their monthly or annual training periods. This is a common problem as new, sophisticated weapon systems are introduced into the Army inventory. The program developed and evaluated realistic part-task simulations supported by interactive videodisc (IVD) for enhanced retention of skills.

The courseware was fielded at three RC units for at least one year at each site. Effectiveness of the training was evaluated by pre- and posttests of soldier performance on written and hands-on tests.

The overall technical goal of the program was evaluation of computer-based training with IVD as a training medium for the Reserve Component. Recommendations were to be made about the implementation of CBT for RC training. To this end, the main technical objectives of the program were to:

develop computer-based courseware
investigate courseware production efficiencies
investigate costs of courseware production and delivery
revise the courseware based on formative evaluation, and
validate the training effects of the courseware.

Of special interest throughout this report are the results of a major study done in this program to investigate methods and successes of estimating costs for development of computer-based training. An exhaustive review of available resources on CBT costing was conducted as well as a survey of over 200 organizations which develop CBT. This study of cost estimation provided insight into the problems that face both purchaser and developers of CBT today. Information from this study is integrated with the discussions of the MTP-RC program in this report to provide a broader perspective on CBT implementation.

<u>This Report Describes the MTP-RC Program and Makes Recommendations.</u>

Several reports have already been submitted and published on research and development done on this program. This final report will summarize the results of these previous reports and present additional salient points not within the scope of those reports. Many of the problems encountered and lessons learned on this program will be applicable to other CBT military training projects beside Reserve Component training.

This report presents the experiences of MTP-RC and makes recommendations in five main sections:

Scoping and Procurement,
Courseware Costing,
Courseware Production,
Fielding and Implementation, and
Evaluation of MTP-RC Courseware.

PROJECT SCOPING AND PROCUREMENT

The survey of CBT developers was conducted to investigate on a wider scale the scoping difficulties suggested by the MTP-RC experience. As a research and development project that required development of a substantial amount of CBT courseware, the MTP-RC program offered unique opportunities to investigate the process of scoping and procuring CBT development. In the original statement of work, the descriptions of the courseware to be developed had to be stated broadly because the SOW included both research into the RC training needs and investigation of advanced CBT capabilities as tasks prior to courseware design. This flexibility in courseware specifications usually is not intended in procurements which are exclusively for CBT development, but changes in scope and/or content have been found to be the norm nonetheless. As the MTP-RC courseware specifications evolved based on the initial research & investigation of the program, valuable lessons were learned in how procurements of computer based training would benefit from statements of work with more detail and prior training analysis. The survey showed that problems with scoping the development effort are endemic to interactive courseware projects today. Common difficulties include defining the size of the project, describing the desired features of the courseware, selecting the skills and knowledge to be included in the training, specifying the use of available media, and adjusting the breadth and depth of coverage. Clear definitions of these aspects of the procurement are difficult, but at some point in the planning and conducting of a development effort these parameters must be set. Until the course scope is based on accurate and detailed knowledge of the skills and knowledge to be trained, the training audience, institutional constraints, and resource limitations, there will continue to be changes in the syllabus, the design, the budget, the schedule, or all. These changes frequently result in delays and increased costs. A cooperative effort between the Government procuring agency and the contractor, with clearly defined responsibilities in the effort, is required to obtain all the information needed to accurately scope CBT projects. This section will examine these problems and make recommendations on how the Government and contractors can cooperate in the procurement process and development stages to meet the Government's training needs.

Although adjustments and classifications of the courseware development were expected in this research effort, the MTP-RC scoping process will be examined to show the difficulties which are also encountered on programs which are not expected to change. This section will describe the MTP-RC scoping starting with release of the SOW, how the scope changed as more thorough analysis was conducted, problems caused by the changes, and recommendations for improvements in the procurement process that could benefit both the Government and contractors. The basic problem is that until a thorough training analysis is conducted, it is not possible to establish what the course will be like, what it will cost, how long it will take to develop, or whether the budget is adequate for the training needs.

Development of CBT Requires a More Detailed Statement of Work than Traditional Training Does.

The statement of work (SOW) for the Model Training Program required development of computer-based training for four MOSs with M1 maintenance responsibilities. Organizational MOSs 45E and 63E are specific for troubleshooting and maintenance of the M1 turret and hull, respectively. Direct support/general support MOSs 45K and 63H are, respectively, turret and hull repairmen with responsibility for the M1 among other vehicles. MOS 45K and 63H soldiers with school training on the M1 have the Additional Skill Indicators (ASI) L-8. Training was to be developed to sustain skills in tasks already learned at the schools and to build skills in tasks that are learned after gaining more experience.

The content of the courseware would thus focus on these M1-related responsibilities. After award of the contract, the specific tasks to be trained were selected from the MOS critical task lists by ARI with assistance from the Ordnance School and Armor School. The tasks were mainly troubleshooting and repairing specific electronic subsystems, the turbine engine, and the transmission of the tank. The contractor then conducted a training task analysis on these tasks to determine the enabling skills and knowledge for these tasks and whether the RC soldiers possessed these enabling skills.

This process of selecting tasks for the course content based on their research value meant that the syllabus was still in flux several months into the project. This was acceptable and expected on this research contract. However, the survey of developers showed that this process is common on regular development projects. This means that the precise content of the course usually was not known to either its sponsors or the contractor at the time it was funded.

The amount of courseware to be developed was expressed in the commonly used measure of instructional hours. The SOW called for development of approximately 240 hours, 60 hours for each MOS. The lessons were to be organized in four-hour modules to fit the typical training time available during weekend drills. The difficulty with hours of courseware was emphasized in the study of cost estimating. Although commonly used, most developers dislike the measure because it gives little clear definition as to the size of the effort. An "hour of instruction" might be the time required for an average student to complete some training, might include remediation, might include optional helps, and might include feedback messages. The nature of an "hour" is very imprecise and SOW's which use it suffer from its lack of precision.

The features desired in the courseware were described in the SOW as interactive simulations, videodisc, gaming, and computer-generated graphics. The applications of these features and amounts of each were to be determined in the design phase, based on the analysis of the content and audience. Like most statements of work, the MTP-RC SOW did not specify complexity of branching, amount or complexity of graphics, simulation fidelity, types of remediation or help, or depth of treatment of the content. The SOW did include a task for the contractor to recommend and design a courseware management system to keep records of student progress.

Scope and Design of the Courses in a Program can only be Clarified After Analysis.

Another result of the changing content of the courseware procurements was that some of the content required design and presentation strategies different from those expected on the basis of the Request for Proposals (RFP). For example the MTP-RC RFP required development of a sample storyboard for a representative task which turned out to be very different from the actual tasks selected to be taught in the CBT courses after the RC-M1 skills were investigated. The sample task was a simple mechanical repair procedure, but the criteria used for selecting tasks once the project started explicitly eliminated such simple tasks and focused on complex electronic troubleshooting procedures and advanced mechanical procedures unique to the M1 equipment.

The survey of developers indicated that it is a common problem in CBT procurements to have changes in content which require changes in design. The content and its required design strategies are frequently unknown at the time of bidding, or change once the project starts. The result is usually either changes in the syllabus, changes in the budget, or both. In many cases discrepancies between the expected and training tasks meant that a contractor had bid development of one type of content, but had to develop content which required very different features, and therefore, had a very different cost.

The design developed for the courseware after analysis of the tasks and the audience included several features deemed necessary to help develop the target skills. Some of the features were:

- long, detailed part-task simulations of procedures,
- extensive graphics to represent tank components in the simulations,
- motivational graphics, such as cartoons,
- extensive on-line help for procedures,
- detailed descriptions of system operations,
- use of graphics, video or both on most screens (Very few screens were all text.), and
- on-screen symbols or "icons" for soldiers to mark with the light pen to move through the courseware.

When the contractor conducted the training analysis for courseware design and development, it became clear that it would not be possible for soldiers to receive thorough training of all of the selected tasks in the limits of the total courseware hours, nor would it be possible for the contractor to develop that much courseware with the time and budget allotted. As a result, the syllabus was adapted and the number of tasks for each MOS was reduced.

Another problem with the critical task list was discovered during the analysis and design phases conducted by the contractor. The entire list could not be included in the course because of time and budget limitations. The training analysis resulted in a decision to include knowledge about operation and function of the subsystems the soldiers would troubleshoot. The complex systems required substantial lessons to explain their functions. In addition, the selected M1 troubleshooting tasks were often several hours long, and their part-task simulations were almost as long. As a result, the number of systems to be covered had to be reduced.

These changes of content and design of the target courseware on MTP-RC, where they were expected are typical of changes on other projects where they were not expected. Surveyed developers indicated that changes in the scope or design features occur on many projects and are one of the most commonly cited causes of cost overruns.

Skills and Knowledge Must be Specified for Objectives and Entry Level Skills.

During the contractor's survey of Reserve Units, it became apparent that most of the Reserve Component soldiers had not completed school courses in these MOSs or ASIs. (The ASI for the M1 for 63H and 45K is L-8.) Therefore, they did not possess the M1-related skill levels that had been assumed by the statement of work. This meant that the training had to include basic skills such as using the M1 Test, Diagnostic, and Measurement Equipment (TMDE), locating components on the tank, and using the special M1 technical manuals. (The technical manuals used the Skill Performance Aid.) This need was the impetus for the development of a common course for all MOSs to familiarize them with the tank and its equipment. This was a major component of the syllabus that had not been anticipated in the statement of work or the proposal. This addition to the course content of the program required that some of the originally desired content had to be deleted from the syllabus in order to stay within the project budget. This experience of MTP-RC is common in CBT procurements because the desired course is specified before a thorough training analysis is complete.

Phased CBT Procurement Should be Studied.

The lesson learned is the MTP-RC course specifications evolved and the information gained from the survey of CBT developers leads to several recommendations for the CBT procurement process. The possibility of phased procurements, in which the analysis phase is completed before the following phases are awarded, should be examined. This would permit a clearer understanding and firmer specifications for the effort.

Methods for bidding and procuring CBT contracts should be studied to see how the methods might be modified to facilitate more accurate specifications of the needed courseware. One suggestion made frequently in the survey and supported by the MTP-RC experience is to conduct the analysis phase of the Systems Approach to Training (SAT) before developing the requirements for the design and development phases. A thorough analysis of the content, the audience, and the resources available would provide information necessary to generate the scope, design, and cost of courseware development efforts.

In some cases the analysis may be completed by the purchasing agency, although the developer will generally need at least a complete review of the analysis, and possibly a partial analysis to gather information not provided by the purchaser. In other cases, the contractor may perform the analysis as a separate contract prior to the procurement of the development project.

Without a completed training task analysis, the choice of media for the project is made without sufficient information. A thorough analysis can support more informed media selection in two ways. Given the training tasks identified by the analysis, the most effective medium or media for the type or types of tasks can be selected. For example, well-founded recommendations on the advisability of video or computer-generated graphics can be made only when these tasks are analyzed. On the other hand, if the main selection of media has already been made by the using agency, the analysis will allow the selection of tasks for training that can be most successfully trained with that medium.

Another advantage of conducting the analysis separately is that it would allow the Government to make choices about the scope of the project and the design of the courseware based on more complete information. The initial analysis should provide detailed data on the real skill deficiencies and provide options for training designs with reliable cost estimates for finished courseware. Without this information, both the Government and the contractor are left to make estimates without sufficient foundation. For example, after analysis of the troubleshooting tasks and the knowledge and skill levels of the RC soldiers, the contractor proposed a training design that included knowledge of the functions of the system components, an introduction to the troubleshooting logic behind the procedure for the symptom, a guided demonstration on a part-task simulation, and practical exercises on a part-task simulation. Only then did it become clear that the budget of the contract was not sufficient to allow such thorough treatment of all the selected tank troubleshooting tasks. Had the analysis work been done previously as a discrete phase, the Government would have had the option to choose a less expensive design, train fewer systems, or expand the program.

In any interactive courseware development, there will be decisions that involve trade-offs, such as effectiveness of media versus availability of media, depth of content coverage versus breadth of coverage, use of more realistic video images versus less realistic computer graphics, and so forth. These decisions are often changed or renegotiated during the contract as the training analysis uncovers details of the needed training. Survey respondents listed changes in the scope of work as one of the most common causes of inaccurate estimates of development costs and lost time during production.

Caution must be used in separating the analysis from the development project. Separate contracts with the Government could lead to a lengthy procurement process. Additionally, in cases where the purchasing agency provides the analysis to the developer, care must be taken to ensure that all of the information that a CBT developer might need is provided or can be gathered. Toward this end, a checklist of information to be provided in Requests for Proposals (RFPs) for development could ensure that essential standard information be supplied or that a task of the contract allows for this information to be collected before the development effort is scoped. A standard analysis should include objectives and performance criteria, audience entry level skills, and required instructional features or strategies.

<u>Statements of Work for CBT Should Include Detailed Descriptions of Courseware.</u>

Even without the thorough training analysis suggested above, the results of the survey indicate that more detailed descriptions of the courseware desired would allow both the Government and the contractor to overcome some of the difficulties of unspecified products and time-consuming, expensive revisions. For purchasers who must make changes to existing training or develop training from scratch, specifying the desired number of lessons or student objectives with descriptions of the level of complexity of branching and graphics may be the most helpful. For example, a developer or purchaser might specify:

> Four simulations with linear branching; two types of help; with 50% video images, 40% computer-generated graphics, and 10% all text pages; with meaningful interaction on 50% of the pages; to meet the objective of enabling the soldier to identify the causes of four common faults of the stated system.

If the procuring agency does not have the experience with interactive courseware to make these specifications, they should get assistance from other agencies or contract the task of writing specifications. The specifications will be done, either explicitly or implicitly, for every CBT project. Explicit specifications allow more intelligent choices about use of resources, and the sooner they are done, the sooner the choices can be made.

Completion of the analysis and even a prototype lesson before the entire project is bid will ensure that most issues are clearer to both parties. Prototype lessons could be used to display exactly what features are required and what type of courseware will satisfy the training requirement.

Student Objectives Should be Emphasized in the Statement of Work.

Soldier performance of troubleshooting and maintenance tasks was always emphasized as the goal of the MTP-RC courseware, but the survey of developers found that on other projects the emphasis is sometimes equivocal. Developers reported that purchasers are sometimes so fascinated with the techniques and features of the CBT medium that the goal of final student achievement is overshadowed.

In the flurry of discussion about defining CBT development efforts, the most important question is often ignored: Do the soldiers learn? There are no generally accepted standards for courseware quality, but certainly a major component of any definition is the students' achievement of the objectives. The measures of courseware and tools to estimate development costs must be built around the issue of quality to make realistic estimates and fairly compare bids. Two developers can bid for the same number of instructional hours with very different processes. The question that must be addressed is: Will the students learn equally well? To this end, courseware developers may find it an advantage to guarantee results rather than a specific number of "instructional hours." Many of the comments from developers in the survey indicated that failure to specify student outcomes clearly contributes to ineffective courseware or excessive revision. The focus of a request for proposals should be on providing all information necessary to ensure that the description of the desired student outcomes are detailed and unambiguous.

The focus on student achievement has other advantages as well. Developers and purchasers would learn to distinguish between strategies and features that help the student and those which are merely fashionable. A focus on the objectives could also reduce the number of revisions, as only changes that assist the student in meeting the objectives need be made.

This focus on student achievement rests on a very critical task--the ability of developers and purchasers to determine, at the beginning of the project, exactly what outcome for students is desired. After communicating with over 300 CBT professionals, the MTP-RC researchers believe that clearly specifying student outcomes would make the single most important contribution to the ability of developers to estimate development efforts accurately and produce computer-based training that teaches.

COURSEWARE COSTING

A Three-Part Study of Courseware Costing was Conducted.

A major research focus of the MTP-RC program was to address concerns expressed by purchasers and developers of computer-based training that current cost estimating methods for courseware development are glaringly inadequate. Accurate cost estimates are equally essential for both purchasers and developers of CBT. Purchasers must have reliable methods of estimating CBT costs so they have a realistic basis for deciding whether CBT is cost-effective for particular training applications. Key factors which contribute to the cost of CBT must be clearly defined and weighted for purchasers to evaluate proposals. CBT developers have also expressed an acute need for effective cost-estimating tools, since methods for accurately estimating CBT development costs are an essential prerequisite for successful project planning and management. A three-part study was undertaken to investigate the current state of CBT development costing methods and make recommendations for improvements in the current process. The study is reported by Jay, Bernstein, and Gunderson (1987).

This study consisted of three parts, each designed to contribute to the attainment of the above goals. Part One consisted of a review of the issues involved in estimating CBT development costs. Sources of information for this section included available literature, research in progress, CBT professionals, and anecdotal information from seven completed CBT projects. Part Two consisted of a survey of almost 200 CBT developers to determine cost estimating practices, identify and rank factors impacting development costs, and collect data on average CBT development times. Part Three included a review of cost models for CBT and the related field of software development, as well as an informal validation of an existing CBT development costing tool. The major findings of the study are summarized here. Additional details on the methods of the survey and the resulting data are included in the interim research report.

Developers Have No Widely Endorsed Measure for Courseware.

Developers reported that no standard method for measuring CBT is currently used. Although the "instructional hour" is most commonly used, it is widely disliked by developers as inaccurate and not reflecting complexity of content, complexity of branching, quality, and other factors. Purchasers using this method have little assurance that an "hour of instruction" will teach the objective or even that it will actually take an hour. Although the purchaser or developer may have in mind a number of hours they would like the instruction to take, it is often impossible to predict delivery time in the computer based medium.

In addition, developers reported including different tasks when costing a unit of CBT, so when purchasers are reviewing proposals, they cannot be sure that the proposals will produce the same courseware. The exclusion of certain tasks, such as analysis, formative evaluation, and management, is likely to have a major effect on the quality and effectiveness of the courseware. Since the effectiveness of courseware is seldom guaranteed, and the development tasks are inconsistent, the review process may be the client's only way to impact quality. Many professionals who contributed to this research would welcome both a standard method for measuring CBT that includes quality factors and a method for making estimates of CBT development times. Most believed that developing measurement and estimation tools would be complex, but valuable.

Developers' Cost Estimates Are Usually Inaccurate.

Most developers report that they are unable to make accurate estimates for CBT development times. Less than 10% are able to estimate within 5% of actual cost. Experienced developers are no better overall at making accurate estimates, but inexperienced developers are more often off by over 20%. However, there is evidence that experienced estimators of development times are better at making estimates than those only experienced in CBT production. Because of poor estimates, many developers are only breaking even or actually losing money on CBT development contracts. De-scoping and requests for additional funds are the norm, and purchasers often do not receive what they expected. However, there is an indication that developers can improve estimates by considering project complexity factors when making estimates.

There are many reasons for inaccurate bids. There is no standardized estimation method and few historical records are readily available. Even when historical data do exist, developers may be reluctant to use it because the numbers are unacceptably high in light of "industry averages," and they believe that future projects would not have similar problems. In addition, developers are often surprised by factors not anticipated in the beginning, such as changes in scope by the client or hardware or software changes.

Developers generally bid on CBT development projects with very little knowledge of the project details. Developers often underbid projects because they fail to anticipate factors such as the required complexity, quantity of courseware, or long review processes. Some developers are now insisting on a complete analysis and initial design before the development project is bid to insure that most of the underlying issues are identified initially and taken into account when making a bid.

The survey of nearly 200 organizations which develop computer-based training found that accurate estimation of CBT development times is not yet common in the industry. Among the major finding are the following points.

- Only 9% of private organizations reported estimating costs within 5%.
- Experienced developers do not report any lower development times than do inexperienced developers.
- Inexperienced developers are twice as likely as experienced developers to be off in estimates by 20% or more.
- For respondents using the instructional hour as the unit of measure, the mean minimum development time for one hour of courseware was 140 hours; the mean maximum was 316 hours.
- The range of development times for the instructional hour was one to 4,000 hours.
- Different developers include different development tasks in their estimates for a unit of courseware.
- The seven highest rated cost factors were, in order: complexity of instructional design strategy, nature and complexity of content, client's demand for revisions, complexity of screen interactions, complexity and volume of graphics, conditional branching complexity, and development team's experience producing CBT.

- o The most frequently used single measure of courseware is the instructional hour, but only 1% continue to recommend it use.

Developers Use Several Methods and Factors when Estimating Costs.

Developers reported use of several methods of estimating the cost of a unit of instruction. Most commonly, "industry averages" of 100 to 400 hours per hour of instruction are used. The reported range of hours required to develop a unit of CBT was from 1 to 4000 hours per instructional hour, with 153 and 316 as the mean low and high in the survey. Although this is close to the industry average of 100 to 400 hours per hour, these broad ranges are virtually useless for estimation without a systematic way of narrowing the range for a specific project. Developers simply must be able to estimate within 10% of cost if profit is an issue. A few developers use their own historical databases to predict costs for projects, and a few others are developing costing tools that include cost factors.

A host of factors were identified during the research as contributing to CBT development costs. The factors mentioned most often and rated as having the greatest cost effect are:

- o Complexity of instructional design strategy,
- o Clarity of project specifications at outset and adherence to them,
- o Complexity of content,
- o Number of revisions/unexpected client revisions,
- o Complexity and number of features (e.g., graphics and helps) and,
- o Experience of the development team, individually and as as a group.

Although several attempts have been made to quantify these factors to yield a unit estimate, none has been proven any more accurate than applying the industry averages.

One commercially available tool for estimating CBT development costs, The CBT Analyst (Park Row Software, 1986), was found to be useful for novices who need an estimate of the cost range to make a decision about whether to go ahead with CBT. However, like other guidelines currently available, the tool cannot be used with confidence to predict the cost of any particular project. The tool does point developers in the right direction by forcing them to focus on the factors that can increase costs.

The more mature field of software development offers promise for the future development of an accurate CBT development costing tool. Because of similarities between software and courseware development, it seems reasonable to apply to courseware the techniques used for measuring and developing software. However, research is necessary before tool development can begin. Recommendations for the steps in creating a CBT development estimation tool are presented later in this section.

Common Factors Affected MTP-RC Development Costs.

Of the seven factors identified in the survey of developers as most affecting development time, several had large impact on MTP-RC production, and are described as follows. The factors which most affected the cost of courseware production for the MTP-RC were discussed in the report "An Analysis of Cost of Computer-Based Training Hardware and Courseware Development for the Model Training Program for Reserve Component Units" (Begg and Bernstein, 1986).

o The instructional design strategies developed in the design phase were complex because part of the purpose of the program was to test the capabilities of CBT to deliver highly interactive training and part-task simulations. There were several types of interactions, a number of presentation strategies used for each lesson, and extensive feedback. This increased the time required for production.

o The content of the course was highly technical information about the electronic and mechanical systems of the M1 tank. Extensive research and writing time was required of the Subject Matter Experts (SMEs), as were considerable interactions with the Instructional Designers (IDs), Graphics Specialists (GSs), and Video Specialists (VSs)to assure accuracy of the course content.

o The screen interactions were fairly complex in that several branching options were available from every screen. Even with the lesson code templates, many hours of coding and writing by the Courseware Developers (CDs) were necessary.

o The strategy for training and testing troubleshooting skills was especially heavy in its use of graphics. The use of motivational cartoons and detailed functional diagrams, which added to the acceptance and effectiveness of the courseware, also added to the hours required for developing graphics.

ɔ Although several of the contractor's personnel had previously worked on CBT projects, the MTP-RC project was their first effort as a team. It took time for the team members to develop communication paths and working patterns. The previous experience as a team was also cited in the survey of developers as a major factor in production time.

Although detailed production figures were not kept for all lessons throughout the production phase, some fairly accurate estimates can be given for the hours required to produce some lessons. Table 1 shows the average numbers of hours required in four labor categories for each of the five lesson types when the process of production with templates was in place and running smoothly. Figures for Video Specialists and Production Coordinators are not included on the table because they could not be apportioned to individual lessons. These figures pertain only to lessons developed with the templates after the template design and coding were stable because the earlier lessons included time for developing and revising the generic templates in addition to coding the specific lessons.

Table 1

MTP-RC Courseware Production: Average Labor Figures in Hours

	Lesson type (number of lessons)				
Labor category	Name, Location, Function (6)	Input, Process Output (4)	Intro (5)	Trouble-shooting (6)	Mainten-*ance (4)
ID	110	110	40	120	155
CD	100	100	60	155	125
GS	50	50	40	80	50
SME	30	30	20	55	75

Note. All figures are +/- 20%.

The difference in costs for the five types of lessons was mainly due to the complexity of the design and complexity of the technical content of the troubleshooting and maintenance lessons.

Further Research on Costing is Recommended.

Many of the approximately 300 CBT professionals who participated in this study of CBT cost estimation indicated that they would welcome a tool to standardize the measurement of courseware and estimation of development costs. However, before such a tool can be developed, a number of key elements must be resolved, including data collection procedures, methods of CBT measurement, and identification of key development factors. The recommendations are listed below.

Further research is needed to identify and validate:

- the most effective means of collecting and reporting data,
- the most effective means of measuring CBT,
- standard descriptors for CBT,
- factors and weights that affect CBT development costs, and
- a method for measuring CBT quality.

Development data from CBT projects should be collected in an accessible database to be used on bidding future projects of a similar nature. Project managers should note major factors affecting cost increases or decreases for future reference. A government requirement of a more detailed accounting of development labor would provide external motivation. This accounting might require that labor hours be reported for each lesson and task as opposed to labor category, as is usually required.

Research should be conducted to structure and validate a cost estimating tool. To develop an accurate cost estimating tool, factors believed to impact the cost of CBT development effort, including quality, must be identified. Scales should be developed for each factor and be tested for reliability. An example of an objective scale for the factor of programmer experience would be 0-2 years, 3-5 years, and 6 or more years. Sample completed projects would then be selected and rated on each factor's scale.

A multilinear regression could be used to identify the factors that are significantly correlated with project development time. The factors would then be validated by testing them with the original sample, and finally with a new sample. Once a cost model has been generated, the rules and weights associated with could be embedded into a computer program.

Validated tools for software estimation have evolved over several years. The development of a comprehensive and standardized tool for estimating CBT development costs is also like to take several years to complete. In the meantime developers require methods for measuring CBT and estimating development times. For purchasers who must make changes to existing training or who are developing training from scratch, lesson or objectives with specifications for level of complexity of branching and graphics may yield the most helpful measurements. Using this method, for example, a purchaser/developer might specify: "Four simulations with linear branching; two types of help; with 50% video, 40% graphic and 10% all text pages; with a meaningful interaction on 50% of the pages; to meet the objectives of enabling the student to identify the causes of four common faults of the stated system with 90% of the students achieving 90% accuracy."

Purchasers who are converting existing classroom training to CBT without significant modifications may find that the instructional hour can still serve as a helpful measurement. In this case the CBT hour would be equivalent to the instruction given in one hour's time in the classroom. However, developers and purchasers should be aware that those using the instructional hour have found it to be the source of many misunderstandings.

Until an accurate costing model has been validated, developers need a more narrow range for estimating an hour than the industry average. Those who do not have a historical data base may find it useful to use a method suggested by Gery (1986) for examining courseware factors and applying development ranges. Caution should be used at the higher ranges of development hours. While Gery lists 300+ per hour as the highest range, developers have reported development hours of 400 to 4000 hours per hour when certain factors are present.

New developers should remember that there are some tasks which must often be done on a CBT project that are not part of the price of all of the units of courseware. These tasks and other costs must be added to the estimate for the development of CBT to ensure an accurate estimate.

Measures of Courseware Should Emphasize Student Achievement.

In conducting the research on courseware costing, it became apparent that the most important question is often ignored: Do the students learn? There are no generally accepted standards for courseware quality, but certainly a major component of any definition is the students' achievement of the objectives. The measures of courseware and tools to estimate development costs must be built around the issue of quality to make realistic estimates and fairly compare bids. Two companies can bid for the same number of instructional hours with very different prices. The question that must be addressed is: Will the students learn equally well? To this end, courseware developers may find it an advantage to guarantee results rather than a specific number of "instructional hours."

Many of the comments from developers indicated that failure to clearly specify student outcomes contributes to ineffective courseware or excessive revisions. The focus of the RFP should be on providing all information necessary to ensure that the description of the desired student outcomes are detailed and unambiguous.

The focus on student achievement has other advantages as well. Developers and purchasers would learn to distinguish between strategies and features that help the student and those which are merely fashionable. A focus on the objectives could also reduce the number of revisions, as only changes that assist the student in meeting the objective need be made. In the MTP-RC review process, some requests for changes were simply suggestions for alternative strategies or presentations that did not directly address the effectiveness of the lesson.

This focus on student achievement rests on one very critical task--the ability of developers and purchasers to determine at the beginning of the project, exactly what outcomes for the student are desired. The MTP-RC statement of work was like most SOWs described by developers in that it did not specify soldier performance outcomes of the training program. This ambiguity led to some delays and extra costs. After communicating with almost 300 CBT professionals, the researchers believe that clearly specifying student outcomes would make the single most important contribution to the ability of developers to estimate costs accurately and produce computer-based training that teaches.

Computer-based training development is a highly competitive field, with many factors complicating the development process. Currently many developers are finding it difficult to make a profit, partly due to their inability to make accurate estimates, and partly due to a misunderstanding by all involved of the complexity and opportunities for cost far above industry averages. Experience in the field, as in the field of software development, will undoubtedly improve the ability of developers and purchasers to work together to develop effective training. The recommendations in this section represent essential steps for defining and systematizing the complex process of estimating CBT development costs. When they are implemented, these recommendations could bring about improvements in the cost estimating process which will be a boon to CBT developers and purchasers alike.

COURSEWARE PRODUCTION

As the contractor planned the courseware production effort for MTP-RC, it became apparent that development of the required number of courseware hours within the program's time and budget constraints would be impossible. Production of CBT typically follows the traditional Instructional Systems Development (ISD) model, setting very general design standards for the course and then proceeding lesson by lesson through design, development, review, and revision. This approach by itself was not considered likely to succeed in the MTP-RC constraints. A major enhancement of the process was developed for analyzing the tasks to be trained because the contract statement of work called for development of over 200 hours of courseware in a relatively short time.

Consequently, the contractor applied an approach to analysis, design, and development that took a course-wide approach, making global decisions that were applicable to several lessons at a time, instead of proceeding immediately to development of individual lessons. This approach was found to be effective in maintaining quality standards across all lessons and increasing efficiency of development of complex lessons. In this section the following main topics will be discussed:

- shortcomings of common CBT production methods for large development projects,
- steps of the MTP-RC production process,
- enhancements to the analysis and design phases developed for the MTP-RC production effort,
- the use and effects of lesson templates as tools for design and development of lessons,
- difficulties with reviewing specifications and lessons in the templated process, and
- recommendations for effective application of the template approach.

Common Courseware Production Methods Focus on Individual Lessons.

In developing the courseware for this program, the Army's Systems Approach to Training was used, and the standard five phases were implemented: analysis, design, development, implementation, and evaluation. The SAT has been very effective in setting standards for development of training materials for the Army with its comprehensive approach for curriculum design for traditional media, such as lecture, workbook, and shop floor training. However, the SAT lacks detailed guidance at the lesson level for CBT and provides very little guidance regarding the more creative uses of the computer as a training medium. Thus, computer based lessons which use capabilities such as simulations and gaming are sometimes designed and developed without a systematic approach for the entire program.

The MTP-RC design team therefore set about to enhance the SAT approach with three main goals in mind. The first was to develop guidelines for analyzing the training tasks so that the capabilities of CBT could be more effectively applied to the training objectives. This led to development of categories of objectives and instructional designs for each category. The second goal was to provide systematic decision-making guidelines for selection of content, instructional strategies, and media for individual lessons. The third goal was to provide design tools and techniques specifically for use with non-linear instructional media.

It was hoped that these guidelines and tools would facilitate communication of lesson content and programming logic. The resulting enhanced design process was called "MacroDesign" because it involved the application of design techniques and tools at the course or "macro" level as well as at the lesson level.

The implementation of this MacroDesign approach and an evaluation of its effectiveness are presented after the steps of production are described.

Steps of MTP-RC Production are Described.

The process used to develop MTP-RC courseware conforms to the Instructional Systems Development model. In the early phases, content selection, task analysis, and training task analysis were conducted by the design team. The design process also added the development of lesson templates as described above.

Production Labor Categories. Five main labor categories were involved in the production of lessons. Instructional Designers developed the overall plan for the design of the learning activities. They selected and analyzed content for inclusion in the courseware and then designed the instruction and the interactions between the soldier and the courseware. In performing these tasks, the IDs consulted with Subject Matter Experts about content, with Courseware Developers about programming code, and with the Government about their requirements. When the lesson templates were completed, the IDs wrote content for the individual lessons.

Subject Matter Experts provided technical expertise on the tank systems and proper performance of troubleshooting and maintenance tasks. In addition, the SMEs provided input on the training audience and reviewed conformance of all material to Army doctrine.

Courseware Developers did the programming in the ADAPT authoring language of the MicroTICCIT system to translate the IDs' specifications for content and interactions into working computer code. The senior CDs also developed the code for the prototype for each template.

Graphic Specialists created the technical drawings, charts, menus, diagrams, and cartoons used to illustrate the courseware content. For the MTP-RC courseware, many of the drawings were drawn on paper, digitized into the computer memory, and cleaned up using the on-line graphics editor. A more advanced graphics package was added to MicroTICCIT near the end of this program, too late to be used for production.

Video Specialists turned the designers' requests for video into a finished videodisc. They developed the storyboard and scripts for the video shoot, supervised the location shooting, and directed the post-production editing.

Once templates were designed, coded, and approved, the development phase began and production of lessons commenced. Most of the lesson development was performed by the prime contractor. Some lessons were written and developed by a subcontractor and reviewed by the prime contractor before submittal to the Government. Some other lessons were written by prime contractor designers and their coding and graphics were produced by the subcontractor. The steps in the development phase are described below.

Step 1. Write lesson specifications. The Instructional Designers wrote specifications for individual lessons for approval by the Government. Since the lessons were using the templates, the strategies were almost the same for each lesson of a type, and the differences were in the specific content and the emphasis of important technical and safety points.

Step 2. Generate lesson content. After Government approval of the lesson specifications, the IDs wrote lessons using content supplied by the SMEs. In the later stages of the program, SMEs were also writing lesson content to conform to the instructional strategies of the appropriate templates. The content at this stage included requests for graphic and video images, requests for unusual branching, special windows on the images, and any other information needed to produce the lesson.

Step 3. ID/SME Review. Lessons were then submitted to another ID for design review and to a SME for content review. Lessons were returned to the author for revisions until the lesson were approved for production.

Step 4. Prepare lesson for production. When the lesson content was approved, the ID submitted it to the Production Manager, who channeled the various components of the specifications to the appropriate production personnel. Graphics requests were directed to the Graphic Specialists for design and input to the system. Video requests were sent to the Video Specialist who turned the ID's requests into storyboards and scripts for the video production. The CD reviewed the lesson, gathered any additional information, and prepared the lesson for entry into the system. The technical nature of most of the courseware required that all personnel interact frequently with the SMEs, who served as a resource throughout the program.

Step 5. Input lesson data. In this phase, the specific text, graphics, and video were entered into the MicroTICCIT system for the lessons. CDs used the code templates as the foundation for all lessons, but it was usual that an individual lesson would require some modification to the template, such as allowing additional pages to describe a system component or combining graphics and video images. Modifications were made as the data were entered. Graphics Specialists designed, drew, and edited the various graphics and put them into the system.

Step 6. CD review. Each lesson was reviewed by two Courseware Developers. First, the CD who created the lessons verified that the data entry was accurate and that any code modifications performed as intended. Revisions were made until the lesson was correct.

Then a second CD reviewed the lesson independently to assure that the lesson worked properly: branches were correct, graphics appeared in the correct place, spelling was correct, etc. Corrections and revisions were made by the original CD.

Step 7. ID review. When the CD's debugging process was complete, the authoring ID reviewed the lesson on-line to assure that it accurately reflected the lesson specifications. Text or graphics sometimes had to be modified by the CD during entry, usually after consultation with the ID, and this review allowed the ID to confirm that the entire lesson was effective. This was not a major design review for two reasons. First, the global design decisions were made earlier for the template, and second, changes in the lesson-level at this time would have greatly increased development time. Revisions were usually made by the original CD.

Step 8. Senior ID Quality Assurance review. The senior ID reviewed the lesson to assure that the design met the design standards and lesson specifications approved by the Government.

Step 9. Video production. At the same time that computer code and graphics were being produced, video production was underway. The Video Specialist used the IDs' lesson scripts and storyboards to develop a detailed scripts, shot lists, and storyboards for the shooting effort. The contractor took a video crew to the Ordnance School and Anniston Depot to tape shots of tank components, procedures, and operations. The program schedule and the video budget allowed no more than one shooting opportunity at each site, and this was scheduled and conducted as soon as possible. As a result, many lessons were developed on-line and received first reviews before the videodisc was ready. As with most CBT projects that involve interactive video, to have waited for the discs to produce on-line and review was not possible within the time of the program.

Step 10. Army review. As on-line production was completed, lessons were sent for review by Government representatives at the Ordnance School. Since the major designs for templated lessons were already approved, the major points of this review were content accuracy and flow of the lesson. Army SMEs verified correctness of all technical content and procedures, and educational specialists reviewed the lesson flow. Requests for corrections and revisions were sent to the contractor. The schedule of video production required that many lessons receive preliminary review without the video content.

Step 11. Integrate video and overlay graphics. Video shots and sequences specified by the ID were integrated into the courseware by the CD. Because production of early lessons had to be concurrent with video production, those early lessons had the video added after initial review. Other lessons, such as the maintenance template lessons, were so dependent on the video that they could not be written until the videodiscs were available. Computer-generated graphics which overlaid video displays also had to wait for the discs. After integration of the video, the lessons were available for final review by the Government.

The Analysis and Design Phases were Enhanced with MacroDesign on this Program.

The decision was made to analyze the training tasks for similarities across tasks, hoping to find commonalities that could be the basis for standard, repeatable instructional designs. As depicted in Figure 1, the process adds to the standard SAT model from Step 3, where enabling objectives are clustered by similarities for development of generic objectives. The figure shows that for troubleshooting and maintaining any of the subsystems of the M1 tank (such as the Computer System (CS), Laser Range Finder (LRF) or Fire Control System (FCS)), the enabling objectives include describing the normal operations of the system and checking equipment. For these common enabling skills found in the analysis of troubleshooting each system, generic enabling objectives were written, such as "describe the normal operations of a system."

Since these generic objectives would be applied many times throughout the course, one effective design strategy for training each of these objectives could be developed and used in each lesson which included an example of the generic objective. The following five generic objectives were identified and targeted for design of lesson strategies:

- o identify the name, location, and function of the components of a tank system,
- o identify the input, process, and output of a system, component
- o identify abnormal operations of a system,
- o perform troubleshooting inspections and tests on a part-task simulation, and
- o perform mechanical maintenance tasks on a part-task simulation.

Nearly 85% of the content of the entire course fit comfortably into these generic objectives.

With these objectives identified, the senior instructional designers on the program began to develop instructional strategies. The result was that design decisions were made consistently across the course, wherever the objectives were similar. Of particular importance for this program was that the consistent use of standard designs for all similar objectives provided the Reserve Component soldiers with a familiar courseware structure for each of their widely-separated training sessions. If the courseware had required the soldiers to become familiar with different types of objectives, stated differently, for each lesson, much of their monthly 4-hour block of training time would have been spent in readjusting to the computer each time. The standardization of the lesson designs allowed implementation of a standard interface for the courseware, even in complex simulations. The standard designs for the lesson types were called templates, which will be described later in this report.

The second goal of enhancing the SAT process was to provide guidelines for making design decisions at the lesson level. The main media selection had been made for this program: the courseware would use a computer-based delivery system supported by interactive videodisc. However, that global decision still left a range of choices for presentation techniques and instructional strategies for the content at the course level and the lesson level. For example, should a particular type of simulation be presented as video images from the videodisc, graphics generated by the computer, or a combination of video image with computer-generated overlay graphics? Should an operation of the equipment be shown with motion video, still video, animated graphics, or still graphics? The factors to be considered included instructional effectiveness, cost of the production choice,

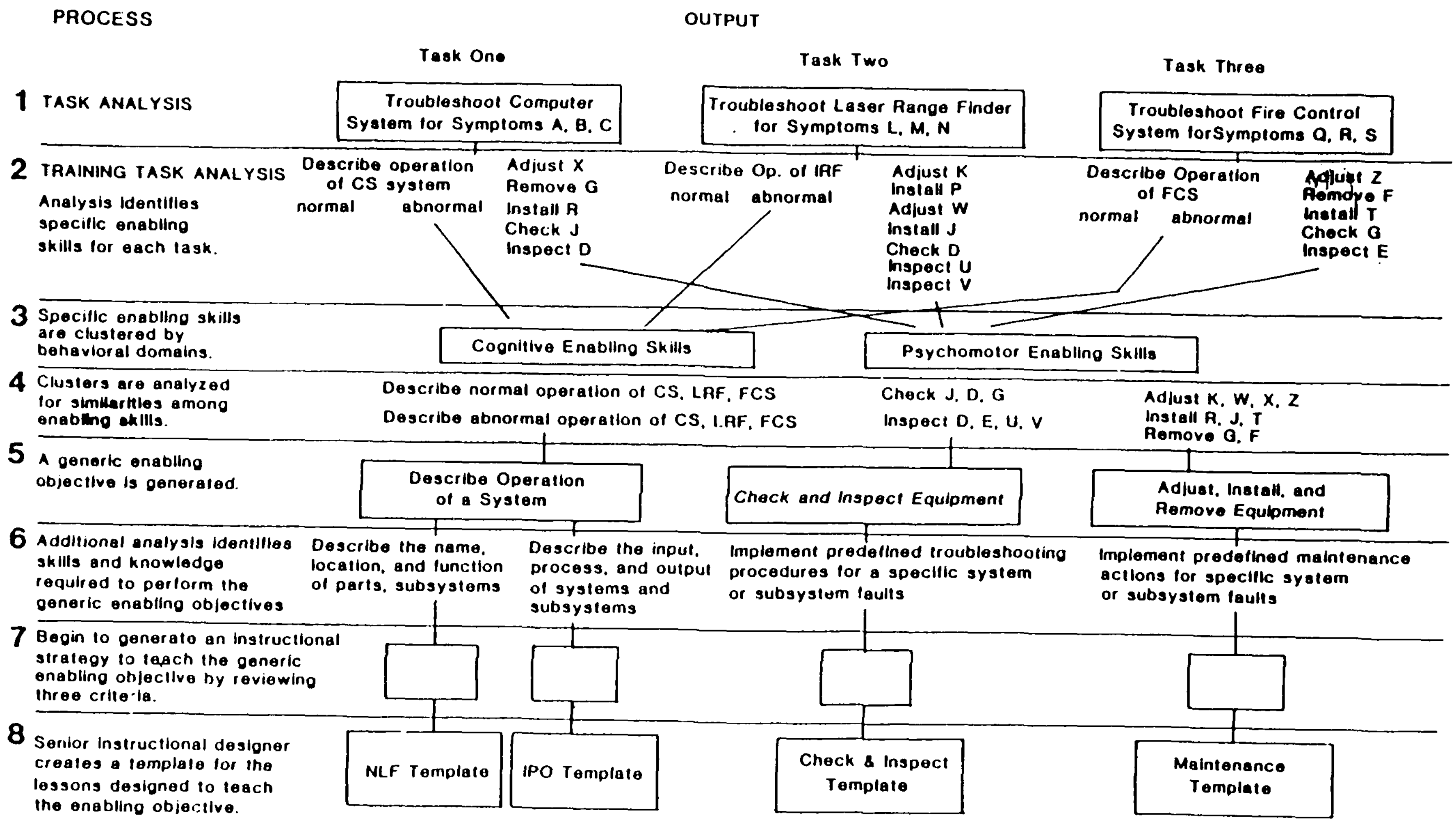

Figure 1. Processes of macrodesign lead to development of lesson templates for generic objectives.

preferences of the using schools, and a host of other considerations. Although these types of decisions are commonly made by instructional designers in developing interactive courseware, the standard SAT process gives limited guidance on selection of the media globally, and virtually none at the lesson level. Faced with the task of designing and developing over one hundred lessons, the MTP-RC development team realized that they did not have the time to make these decisions from scratch for each lesson or module.

Both to facilitate the decision-making process and to set program-wide standards of design quality, the designers developed a set of guidelines for making design decisions at both the course and lesson level. The guidelines were presented in the Appendix to the report "An Enhanced Instructional Design Process for Developing Interactive Courseware." The guidelines which were found to be especially important for this program aided in the selection of: feedback levels, passing criteria, learner control, visual fidelity, simulation fidelity, performance error fidelity, and level of guidance. These guidelines set standards for selecting options for each of these issues by highlighting the impact of the major factors affecting the program as whole and the lesson under development. The major factors for this program and any ISD project are: the audience the training is aimed at, the institution sponsoring the training, the content of the training, and the resources available for the development and delivery of the courseware.

These guidelines greatly simplified and facilitated the design and production process. As the first lessons were designed, the major issues were identified and guidelines set for all the ensuing lessons of that type. This use of high-level, or global, guidelines for design decisions both increased the quality of the resulting lessons and reduced their cost because more experienced senior designers could set the standards that would be implemented by less experienced designers on all lessons. For example, it was decided that for mechanical maintenance procedures, motion video sequences would be used only when *the procedure specified a particular type of motion, such as rotating the transmission.* Simple mechanical steps, like attaching slings to the the transmission, would be shown with video stills. This consideration of visual fidelity was influenced by the content (the task being trained) and the resources available for production. Motion video is more expensive to produce, and the video budget was limited. These guidelines aided the uniform implementation of design decisions throughout the program. Although not exhaustive of all considerations, these guidelines will be useful to designers on other programs because they elucidate many considerations that designers have often had to make either intuitively or fortuitously. For example, the guidelines for level of guidance in a task by the computer remind the designer that extensive guidance will require extensive involvement from subject matter experts; if this resource is not available, extensive guidance may not be possible.

Use of Lesson Templates in the Design and Development Phases Improved Quality and Increased Efficiency.

The third goal in enhancing the SAT process was to develop tools and techniques for both content writers and programmers working on individual lessons. The MacroDesign process of designing courseware as described above resulted in detailed instructional strategies for each lesson type. For each of these strategies, complete computer code was planned and developed, including reusable routines or "macros" for presenting screen icons, routines for branching, routines for judging and recording answers, and all of the other code required for a complete lesson. These programs, along with the design strategies they implemented, together make up lesson "templates"--detailed, reusable patterns for lessons that are implementations of sophisticated instructional strategies for types of lessons, from presenting the lesson objectives to reporting the test score. It should be noted that although it is now common for courseware programmers to write reusable routines for interactions of portions of lessons, it is uncommon to write reusable programs for entire lessons. The ideal for this endeavor was to develop program code for each lesson type so complete and flexible that the programming for each individual lesson would be reduced to entering content and data specific to that lesson. This goal could not be reached, but approximately 85% of the code for these very complex lessons was written and reusable in each lesson. Each template consists of a fully prescribed instructional strategy, a set of screen display characteristics, and a structured system for student interaction.

Instructional strategies were developed for each of the five common objective types mentioned above, and as modules were developed for the various subsystems of the tank, the templates were implemented. The two main contributions of the template use to the MTP-RC production effort were that the templates were effective in ensuring a high level of integrity in the instructional design and program coding across all lessons, and they did make the writing and coding of lessons more efficient than it would have been without them. Several of the templates have been used on subsequent CBT programs for ARI with only minor modifications. However, there were some difficulties in using them which will be described in this section.

Reviewing MacroDesign and Templates can be Difficult.

A major difficulty encountered in using MacroDesign was review of the strategy and designs incorporated in the templates. It is a typical problem in CBT design that the complex interactivity made possible by use of the computer is hard to portray on paper documents. The instructional techniques chosen for presenting material, providing practice, and conducting tests for a generic objective type are set early in the ISD process. (In fact, the MacroDesign step of developing templates is on the transition between the design and production phases.) These design templates are then approved by the Government before lesson production begins. The difficulty was that it is hard to envision the application of a single instructional strategy pattern for a number of lessons which cover apparently disparate content. For example, the same strategy (the "Name, Location, and Function" template) was used to teach the operations of the computer subsystem, the transmission, and the laser range finder subsystem. The level of abstraction required to find commonalities across these objectives is somewhat at odds with visualizing the concrete, specific interactions provided to the soldier on the computer screen. One alternative would be to design the template, develop a first lesson, and use that lesson as the review and approval vehicle. However, developing a first lesson requires that virtually all of the template coding be written to implement that lesson. If the template is not approved, then substantial time and money will have been lost. A smaller, prototype lesson can be developed, but if the prototype is small enough to make a difference, it probably will not contain enough content and will still not facilitate generalizations to other potential lessons by reviewers. The traditional approach of storyboards can depict the presentation strategies, but breaks down when depicting the interactions possible with CBT when the branching begins to get even a little complex.

Review of the first MTP-RC templates unsuccessfully used a software engineering technique called "pseudocode." Pseudocode is a technique for describing computer programs that uses programming-like descriptions of the computer's activity, structured in a flow somewhat like the actual code will be written, but using natural language. This technique worked fairly well for communicating the templates to programmers, but was not successful for those with little programming background. Most reviewers, designers and especially SMEs have no programming background and found the pseudocode impressive but not helpful for understanding the proposed interactive instructional strategies.

The later templates were reviewed through a combination of storyboards and small prototype lessons which included most of the key interactions. This technique was more effective, but did cause some delay in production. Fortunately, once the first templates were approved, production could begin on lessons of that type while templates for the other types were being developed.

Some problems were encountered in reviewing lessons developed with the templates. Approval of a template requires a leap of faith on the part of the Government. The templates themselves were difficult to review for approval of the instructional strategies they embodied when they were presented on paper. Even when the prototype lessons were presented, some reviewers found it difficult to separate the generic strategies from the lesson as implemented with specific content. Part of this difficulty arises from the fact that the process of instructional design generally involves dealing with content abstractly, for example, determining whether particular content is a skill or knowledge objective. The fact of life is that most personnel with the technical training and background to evaluate technical accuracy do not have the design background to evaluate the abstract, formal design, and vice versa. After viewing a few lessons, most reviewers were able to provide helpful criticism to the design group, but after several lessons are produced with templates, the major changes in the templates would defeat the purpose of developing production efficiency, because they would have to be rewritten.

Based on the experience of the MTP-RC program, the best suggestion for reviewing the templates for approval of design would involve three steps: 1) provide storyboards for the design because most CBT reviewers will be familiar with that format; 2) produce a prototype lesson with sample content so actual interactions can be seen on screen; and 3) provide extensive briefings to all reviewers on the rationale and strategies of the templates. The need for communication may require that contractor personnel be available on-site for extended periods to discuss decisions made for individual lessons and comments made on their effectiveness.

A common problem with military CBT development is that SMEs assigned to the project will often rotate to new duty assignments during the life of the project and be replaced by new SMEs unfamiliar with the overall context of the program or the decisions made early in the program. These new reviewers must have thorough briefings on the program to make worthwhile contributions without slowing down the progress of implementing previous decisions.

Another difficulty faced with integrating review comments into lessons is that reviewers' requests for apparently simple changes in the screen display or presentation of information may in fact be difficult or impossible. This problem is not peculiar to the template approach of production. The limitations may arise from previous, global decisions, from lesson-specific code decisions, or from the operational parameters of the authoring or delivery system. For example, inserting additional steps in a troubleshooting part-task simulation looked like a simple change in screens. However, it was a very complex and cumbersome task because of the programming design required by the parameters of the authoring system. Stated succinctly: simple isn't easy, and on-site contractor representatives may be necessary to explain the options available.

It was a great inconvenience for Army reviewers to have to review the first lessons without the video integrated. Since early lesson production was concurrent with video production, this situation was virtually unavoidable, and the timing of video integration often poses problems with CBT production projects. An alternative would be to deliver for review first those lessons which rely mainly on computer generated graphics. But this program was intended to rely heavily on interactive video to present the new equipment to the soldiers and most of the templates used extensive video. The two templates that used mainly computer-generated graphics instead of video (Troubleshooting and Troubleshooting Introductions) were not designed until later in the project. Another alternative is to approve the generic template design or instructional approaches with a prototype lesson and postpone review of lessons until video is available.

Another lesson learned during the course of this program was to program a review mode into the lessons. Contractor personnel initially encountering frustration and difficulty in locating the pages to which reviewer referred in comments on a lesson with four hundred screens. The senior programmer then added to the troubleshooting template a review mode which displayed an identifying screen number for the reviewer to record with comments on the screen or interaction. This made it easier for contractor personnel to locate and correct the error, and easier for the Government to locate and verify that the correction had been made in the final delivery.

Recommendations are Given for Use of Templates for Courseware Production.

There are some limitations in the general application of the template approach to courseware development. Complex templates can be developed for a program cost-effectively only if the program is fairly large. The design and coding done for the templates could be spread over many lessons on this program. If existing templates are not available for smaller projects, it may be better to design and develop the lessons individually, or to develop reusable routines on a smaller scale than templates. Even on large projects, it is important to analyze the training objectives to see if they do fall into categories before attempting to develop templates. If there are several types of lessons, several templates may be required.

The effectiveness of lessons produced with templates depends on the appropriateness of the template's instructional strategy and the quality of its coding. The use of templates does not, by itself, guarantee high quality courseware. If the strategies are not well designed or the program is not well coded, the courseware will not be effective in training the objectives. If the strategies of a template are not appropriate for a particular objective, the template will not provide an effective framework for the content.

Templates do not necessarily have to be complex strategies, but the MTP-RC statement of work called for designs which utilized and tested the capabilities of computer-based training to provide complex and interesting training interactions. The use of instructional templates which combine instructional strategies and program code resulted in consistent user interface and uniform quality throughout the course.

Several lessons were learned about the production process. The templates for this research program required extensive time to develop because they employed sophisticated design techniques and complex computer interactions. New complex templates can be developed cost effectively only for fairly large programs which will have several lessons of a type. It is suggested that ten lessons is a minimum number to justify complex templates. Even on large projects, it is important to analyze the training objectives carefully to see if they do fall into categories before attempting to develop templates for them. Templates do not have to be complex, but the MTP-RC statement of work called for designs which utilized and tested the capabilities of computer-based training to provide complex and interesting training interactions. An alternative for programs that are smaller or have fewer occurrences of generic objectives is to develop reusable routines that handle recurring types of interactions, such as answer judging, video loops, or standard feedback.

It was felt that the use of instructional templates contributed to the overall quality of the courseware, because they laid down effective strategies that were uniformly applied to many lessons. The use of templates does help to assure uniform quality of courseware, but templates alone do not assure high quality courseware. Individual lessons are likely to be good only if the generic strategy is good; a poor design repeated several times is still a poor design. Design of templates requires more attention than design of a single lesson.

Another difficulty experienced in production was in subcontracting part of the production effort on this experimental program. The approach of comprehensive instructional templates required extensive communication between instructional designers, courseware programmers, and subject matter experts. When some of the lessons were under production at a subcontractor's site, communication about templates was difficult, and the templates were not implemented uniformly at first. The lack of SMEs at the subcontractor site was an especially limiting factor in assigning production efforts.

FIELDING AND IMPLEMENTATION

When the courseware was completed, three MicroTICCIT systems were installed in RC units. Soldiers in the appropriate MOSs were enrolled as subjects in the evaluation and students on the computers. System operators were trained at each site to run the computer to make the training available to the soldiers. To evaluate the effectiveness of the training a pretest and a posttest were administered to each soldier in the study. This section of the report presents the experience gained in delivering computer-based training at the RC units and resulting recommendation for fielding.

Systems were Fielded at Three Reserve Component Units.

The sites for the fielding were selected by ARI and TRADOC in consideration of several factors. For the evaluation of the effectiveness of the training, a representative sample of soldiers in the four MOSs was required. Units with these MOSs were selected if they would have responsibilities for M1 maintenance upon mobilization. Units connected with divisions with which M1s had been or would soon be fielded were sought. For these units, computer-based training could meet a real and present need for M1 training. A survey of RC maintenance units was conducted by the contractor to provide information for this decision. Two additional factors were used in selecting sites. Units located in the eastern part of the country and reasonably close to sites with M1s (such as the Ordnance School and Fort Bragg) were selected to reduce expenses for travel of contractor personnel. The final factor was willingness of the unit officers to cooperate with the administrative activities involved with this trial fielding.

The units selected and the dates when the computer-based training was available are presented in Table 2. The training was available from the beginning of the fielding to the evaluation posttest.

The units were informed of their selection during the first year of the program, and each site was visited by the contractor and/or ARI personnel at least once while the courseware was being produced. In early 1986, formal briefings were held at each unit for the State Training Officer, unit Commanding Officer, and unit Training Officer to acquaint them with the purposes and procedures of the program and to coordinate personnel and equipment needs for the trial fielding. The systems used to deliver the courseware consisted of a host minicomputer and three to six soldiers workstations, which included a microcomputer, a video screen, and a videodisc player. All units made available appropriate facilities to the program, either assigning current classrooms or remodeling another room.

Table 2

Fielding sites and training dates

Unit and Location	Dates used for training
195th Heavy Equipment Maintenance Company (General Support) Westminster, Maryland	March, 86 - June, 87
2198th Heavy Equipment Maintenance Company (General Support) Dagsboro, Delaware	April, 86- June, 87
Detachment 1, 2nd Battalion, 252nd Armor (Organizational Support) Red Springs, North Carolina	August, 86 - August, 87

The 195th is a U.S. Army Reserve unit, and the 2198th and the 2-252nd are National Guard units. Most RC maintenance units are Direct Support (DS) or General Support (GS) units. The 2-252nd is an organizational unit, assigned to round-out a division from Fort Hood.

Each site received a complete MTP-RC system, consisting of a host computer, individual soldier workstations connected by a network to the host computer, and the program code for the courseware, installed on the system. Each student workstation consisted of a microcomputer connected to the host, a video display screen, and a videodisc player controlled by the microcomputer. The number of workstations at the sites varied from three to six. Workstations were sometimes moved between sites to meet the training schedules.

Each unit appointed a system operator to be responsible for routine operations on the computer, such as bringing the system up, loading courseware, registering soldiers in the computerized course management program, performing routine computer maintenance procedures, diagnosing minor computer problems, and assisting soldiers with difficulties. These routine tasks are required to keep the systems operational. Each system required an operator to perform these duties, even though the courseware was designed so soldiers as students needed no background or previous experience with computers to use the training program. As the systems were installed at the units, at least two soldiers from each unit were trained as system operators by the contractor.

During the training period, the contractor's field representative visited each unit every 4-6 weeks to report on system usage, assist site operators with difficulties, coordinate corrections of courseware errors, and collect usage data. Both the field representative and the contractors' courseware development staff were on call to assist the operators at all times, including during weekend drills.

System Use by Soldiers is Reported.

Once the systems were installed, the soldiers began using them to receive training during weekend drills and extra, week night drills. At the 195th company, some soldiers also spent a portion of their annual training time on the MTP-RC system. Several soldiers who were not a registered as subjects in the study (either because they joined the unit after the study began or because they did not have one of the 4 MOSs) also used the courseware to learn about the tank. Usage of the system is shown in Table 3 for subjects in the study.

Table 3

Total hours of computer use by groups of soldiers in each MOS at fielding sites

MOS	n	Hours
	195th Company	
63H	6	260
45K	6	111
Both	12	371
	2198th Company	
63H	12	330
45K	2	38
Both	14	368
	252nd Armor	
63E	10	131
45E	9	72
Both	19	203
	All sites	
63H	18	260
45K	8	149
63E	10	131
45E	9	72
	All 4 MOSs	
All	45	612

Note. Hours of use are shown only for soldiers serving as subjects for the courseware validation. The times of other soldiers who used the system are not included here. Some registered subjects did not finish their assigned courses.

Reserve Soldiers had Limited Time for Research or Training in any Medium.

A major difficulty encountered at all sites was the limited time available for soldiers to spend on a research project. The Reserve Component soldier faces a heavy training schedule for both individual task training and unit tasks. Unit commanders and training officers find it difficult to achieve all mandated training goals in the time available. Although the MTP-RC courses were directly related to MOS responsibilities of the soldiers, they were not approved as MOS-producing courses and did not count toward on-the-job training. With so many demands on their allotted training time already, soldiers understandably could not devote time to this project even when they were interested in the content. In addition, some training activities require that the units drill offsite. In those cases, a soldier had to miss the unit training and assemblies to take the individual training on the computer.

For the purposes of this research project, the state-level National Guard commands were able to allocate additional training funds to pay soldiers to come in on extra time to take the training at the 2-252nd and the 2198th. This made more time available because the MTP-RC training did not take time away from other requirements. Financial limitations will probably prohibit this approach for a full-scale fielding of CBT training. Programs to field this courseware or other CBT programs will have to face the problem facing all training for the Reserve Component--the shortage of time for the many training requirements. To the extent that CBT can deliver effective training in less time than other training media, it can help save time.

The MTP-RC design team tried to design the course lessons and simulations into four-hour modules to fit the typical time period allotted for individual training during an RC weekend drill, as requested by the statement of work. In fact, soldiers seldom have four hours straight for training during a typical drill period. Most of the knowledge lessons were short enough that they could be fit into shorter periods. However, the part-task simulations of lengthy procedures usually required at least as much time as the real procedure--sometimes as long as five or six hours. When possible, simulations should be broken into shorter sections. For procedures where continued attention to detail over a long period is critical to correct performance, then training on the simulation should be regarded as worthy of the time required.

Command Emphasis is Essential for Success.

Command emphasis is essential for success of a training program. This program was initiated to assist RC units in meeting their training problems. CBT programs like MTP-RC can provide part-task simulations to help overcome the lack of new equipment for training. CBT cannot, however, overcome the lack of time available for training on all tasks. Even when soldiers are eager to learn about new equipment, as many were with this M1 training, there often is no time for it after regular maintenance duties, group training, assemblies, etc. Only if state and unit commanders emphasize and support a training focus will soldiers be able to have time for it. Commanders must be thoroughly briefed and kept informed on the status of a program.

As a research project, MTP-RC fielded training materials that were not yet validated as on-the-job training or MOS-producing courses. The lack of official credit for the training sometimes made soldiers and commanders reluctant to allocate precious training time to the project. Computer-based training will be more readily integrated into the unit' training program if it carries official status.

Operator Training and Support is Essential to Success.

Computer-based training on networked computer systems such as the MTP-RC system has generally been implemented at full-time training facilities such as service schools with large student populations and full-time training staff. In these situations, there was generally a staff person or persons assigned as operator of the system, with responsibility for performing routine maintenance and operations, assisting students, and supervising the computerized record-keeping system. The Reserve Component units had fewer students than schools , but also fewer staff to support training activities. There was concern that the RC personnel might not be able to handle the computer.

The MTP-RC experience was that the CBT was not a "turnkey" system. All operators required continued support after their training. With the contractor's support, the soldiers responsible for the systems were able to handle most operator's responsibilities after the three-day training program. At one site, the operators' hesitation in asking for support resulted in a delay of making the second tape set of the courseware available to soldiers at the site.

An area in which support to the operators was critical was maintenance of the hardware and software. Generally, the operators were only stymied when they encountered bugs in the courseware or unusual system malfunctions. The field representative assisted in periodic maintenance and helped the operators determine if difficulties were being caused by hardware malfunctions that could only be recognized after long experience. In these instances, contractor's support personnel were usually able to provide assistance over the telephone.

Each of the three systems required replacement of its data storage disk once during the three-year program. Diagnosis and repair of this problem required 2-5 days each time. Training was prevented for a full weekend at one site because of the disk failure. The computer boards which created the video displays for the workstations also had difficulties. These "video overlay" boards were extremely sensitive to physical shocks and to ambient temperatures over 75 degrees F, and repair of these boards often required 3-4 months. To keep workstations on-line, boards were sometimes exchanged shared between units. Even when individual workstations were down for repair of the video overlay boards, the systems as a whole were available for use on the other workstations. Some other hardware and software problems had disrupted the courseware production process, but did not hamper delivery.

System operators should be trained and supported. Ideally, the operator should be permanently assigned to gain the advantage of experience with the system. The special MicroTICCIT system configured for this fielding reduced the level of skill and training required of the on-site operator for routine operations, but support was required to keep the system up. The simplified courseware loading operations described earlier reduced the demands on the operator's time and technical competence. Complex computer systems offer sophisticated training capabilities, but require more attention than older, more familiar media. It is recommended that a travelling field representative be provided to offer assistance for non-routine problems, refresher training, and training for replacement personnel. This support staff should have more extensive knowledge of the computer system and the courseware syllabus.

A Technique to Overcome Data Storage Limitations on the Computer had Mixed Results.

During the development phase, it became clear that the extensive graphic required for the courseware, especially the troubleshooting simulations, would exceed the storage capacity of the MicroTICCIT systems available for the program. The three systems had storage capacities of 50, 65, and 100 Megabytes of data, and the courseware was estimated to require 130-140 Megabytes of storage. It was felt that if the site operator, usually the unit's training officer, would have to continually load, process, and unload lessons to meet the changing needs of the unit, the time demand would be excessive and the entire program would be jeopardized.

A special configuration of the MicroTICCIT system was developed by the contractor with technical assistance from Hazeltine. With this system, each site received 2 to 3 sets of computer tapes, each of which contained one-third to one-half of the lessons required at that site. With these special tape sets, the operator could change the online courseware, which might be as much as thirty lessons, in one hour. Without such tape sets, changing each lesson would require up to five hours each. A disadvantage of the tape set for delivering lessons is the decreased flexibility in making available lessons from different parts of different courses to students depending on how much of the course they had finished. Since it was expected that for this trial fielding, most of the soldiers would start the program at about the same time and all had about the same length of time available for completion, the best option was to use the special courseware tape sets. Another disadvantage of the tape set method used to deliver the courseware is that it becomes more difficult to make changes or updates in the courseware. Another disadvantage of the tape set scheme was the time required by the contractor to modify the MicroTICCIT operation system and produce the tape sets. Still, it was considered better to take a lot of contractor operator time than to require a prohibitive amount of on-site operator time.

In selecting and configuring the delivery system for the field, it is important to choose one with a large enough data storage capacity to handle the courseware needs. It may be necessary to design the courseware and get a rough size estimate before deciding on the system. Many systems are available with varying storage capacities. Larger capacity can allow delivery of more programs on one system and create more flexibility for scheduling training for soldiers. Systems such as the Electronic Information Delivery System (EIDS) allow flexibility by simply changing diskettes in the computer and videodiscs in the disc player. New storage technologies are emerging which use the videodisc as a storage medium for programs and data, as well as video and graphic images. This approach may overcome some of the storage limitations currently faced in delivering complex part-task simulations.

<u>A Suitable Hardware Environment must be Prepared.</u>

Some modifications or improvements to the facilities at some units are recommended to keep the computers functioning smoothly and reliably. These improvements are air conditioning and electrical system protectors. Only the 195th lacked air conditioning in the computer room by the time of fielding. In spite of ambient temperatures over 85 degrees, the computer did not malfunction. Soldiers, however, experienced discomfort in the environment. For installation of CBT systems which use large minicomputers, air conditioning is recommended.

Electrical circuits to the computer room should be adequate. Ideally, the computer room will have a dedicated branch circuit to avoid line fluctuations caused by other equipment in the building. A Surge protector should be installed to protect the system from large voltage fluctuations, which can damage the hardware and result in loss of student records and downtime for restarting or repairing the system. At 2 units, the host computer was completely shut down after each use to avoid damage from voltage surges caused by lightning storms in the area. On restarting, the systems exhibited unreliable behavior until they had warmed up for a day or longer. If they had been protected by surge protectors, they could have been left running and available at all times.

The computer room should also have a telephone line for support for the operator for unusual problems. The support personnel often need to discuss operations with the operator during the operation. In addition, with a modem hook-up over the telephone, the support personnel can sometimes diagnose and solve the problem for the operator.

EVALUATION OF MTP-RC COURSEWARE

Two types of training evaluation were conducted for this program. First, a formative evaluation was conducted by the contractor to assess the courseware design before completing and implementing the courseware. The formative evaluation covered overall design of the courseware, student interface, presentation strategies, level of technical content, and testing strategies. Some revisions of the design and content were made as a result of this evaluation. After the training system was implemented at Reserve Component units and soldiers had completed all or most of the course for their MOSs, a training and transfer evaluation was conducted. This evaluation examined: 1) if soldiers achieved the training objectives using the courseware, and 2) if skills learned on the computer transferred to the tank, resulting in improvements in task performance. Testing for the training and transfer evaluation was design and conducted by the contractor, and the data was analyzed by ARI.

Some Design Modifications were made with Formative Evaluation Input.

Formative analysis of the courseware was conducted to determine the need for changes in instructional design, presentation strategy, or content. Two types of formative evaluation were conducted simultaneously by the contractor:

one-on-one sessions in which proctors watched soldiers take representative lessons and then discussed the lesson content and format with the soldier, and

administration of a hands-on test before and after the lesson.

To conduct the one-on-one evaluation, the contractor administered representative lessons to recent graduates of the Advanced Individual Training (AIT) MOS or Additional Skill Indentifier (ASI) courses at the Ordnance School and Armor School in early 1985. Students were observed as they went through the courseware, and notes were taken whenever students seemed to have difficulties with the presentation, design, or content of the lessons. Sometimes soldiers were interrupted and asked what their difficulty was or why they were hesitating. A questionnaire about the course was administered, and each student was debriefed to determine attitudes toward the courseware.

Graham, Shlecter, & Goldberg (1986) evaluated the transfer effecti eness of a lesson from the MTP-RC training with soldiers at the Armor School Soldiers who received the simulated troubleshooting training made fewer errors r time on hands-on troubleshooting procedures than did soldiers trained under conventional methods. The comparisions were, however, limited by ceiling effects. The skills and knowledge developed in the exercises also generalized to a troubleshooting task not specifically trained in the courseware. This generalization was attributed to the fact that soldiers were trained and give practice on properly using the TM and test equipment.

After analysis of the information gained from the test scores and from student comments, the following conclusions were reached on design and development issues that were of concern.

- o The "icons" or symbols used for selecting tools and performing actions in the simulations were too small and too close together for easy selection with the light pen. In general, the light pen required an unreasonable precision in use. The icons were made larger and separated.

- o Soldiers had little previous practice with some of the M1 test equipment. The Course One material on the test equipment was expanded with more detailed explanations and practice on the equipment.

- o The purposes and uses of the icons were readily understood; most soldiers were comfortable with the simulations within an hour.

- o The design of the troubleshooting simulations reinforced the habit of carefully selecting test points on electronic equipment. Therefore, the screen design which required careful selection was retained.

- o Soldiers expressed that performance of the troubleshooting tasks was more satisfying after gaining the lessons's understanding of the reasons for the procedure. Previously, they had simply followed the procedure without knowing the reasons.

- o Soldiers responded favorably to the cartoons used for motivation.

- o Soldiers had limited familiarity with the format of the technical manuals. Nearly all soldiers commented in debriefing that being forced to follow the manuals exactly in the simulations was good practice.

In general, the design of the courseware and the level of detail in the presentation of knowledge about the tank subsystems was evaluated to be appropriate and likely to be instructionally effective when implemented. Changes as described in the points above were incorporated into all lesson to which they applied. The template approach to lesson coding facilitated many of these changes. For example, changing the icons required only that the courseware developers change the coding routine which created the icons on screen, and insert the new routine once into each troubleshooting lesson. In the traditional approach to coding courseware, it would have been necessary to reprogram individually each of the hundreds of screens on which the icons appeared.

<u>The Training Transfer Evaluation Showed Improvements in Task Performance.</u>

For the transfer evaluation, the contractor and ARI developed and administered written and hands-on tests of the skills targeted in the training to determine if soldiers had achieved the training objectives and if the training transferred to the tank. The written test covered knowledge about the tank subsystems, safety, and procedures. The hands-on tests covered troubleshooting procedural tasks trained in the courseware. Both tests were administered as a pretest, including hands-on tests on M1 tanks at the Ordnance School for DS/GS and Fort Bragg for organizational in April, 1986. The posttests were administered in July and August, 1987, at the same sites. Soldiers took the tests at the test site closest to their units.

The procedures and results of the transfer evaluation were reported by Graham (1987). For the hands-on testing, soldiers performed on the tank truncated troubleshooting procedures from the MTP-RC course. Trained monitors rated the soldiers GO or NO GO on each major block of the procedures. If all blocks were GO, the soldiers received a GO for the entire procedure. The primary performance measure was percent GOs on the hands-on procedures. Figure 2 shows that all four MOSs showed marked improvement from the pretest to the posttest. Combined across MOSs, performance of the 35 soldiers improved from a 36% GO rate on the pretest to an 82% GO rate on the posttest. Since the M1 troubleshooting procedures require exact performance of the steps in sequence to correctly diagnose faults, this increase in error-free performance has practical importance.

Analysis of the written tests further indicated that the MTP-RC training was effective. The written test scores of the DS/GS soldiers indicated that their M1 tank knowledge and skills were considerably below levels of recent AIT graduates and that MTP-RC training helped reduce that difference. The written scores suggested that the job knowledge and skills of the organizational soldiers are at about the same level as recent AIT graduates, both before and after training. These soldiers from the 2-252 AR have M1 tanks in their units and routinely maintain them. Detailed description of the evaluation and analysis of the results were presented by Graham (1987).

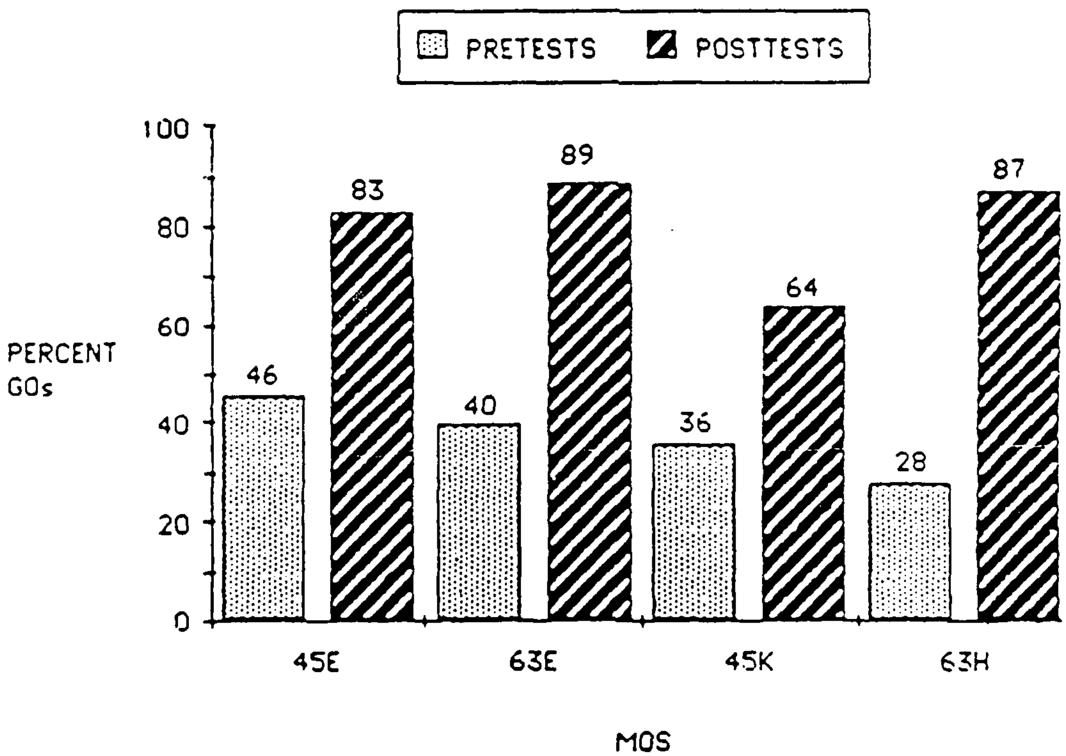

Figure 2: Hands-on Pretests and Posttests for Four MOSs

SUMMARY

This report has evaluated the effectiveness of CBT for RC units and made recommendations on producing and fielding CBT.

The introduction of new, sophisticated equipment to the Army inventory presents special training challenges to Reserve Component maintenance units. They must train and sustain skills in troubleshooting and maintenance on the equipment, but have little or no access to the equipment, limited expertise in the equipment, and limited time for training. The Model Training Program for Reserve Component units was a research and development program conceived to investigate the utility of computer-based training with interactive videodisc as a medium for delivering training to RC units. Interactive courseware with part-task simulations was developed for four MOSs with maintenance responsibility for the M1 Abrams tank and fielded at three RC sites for trials. Development of a large program of courseware also allowed investigation into the process of development.

The evaluation of the MTP-RC courseware showed that soldier performance on trained troubleshooting and maintenance tasks improved significantly after training on the courseware. Although other factors may have affected performance, it is reasonable to conclude that the training effect was real and significant. In addition, response of the soldiers to the courseware was positive and enthusiastic.

For a CBT program to be successfully implemented at RC sites, several conditions must be met. The heavy training schedule already facing these units demands that any new training programs--in any medium--must have Command emphasis. The MTP-RC courseware was designed so that soldiers could use the system without prior experience with computers, but a trained computer operator was still required to support the soldiers. The operator also needed training and support to perform required operations on the computer.

In addition to developing and evaluating the courseware, this program also included an investigation of the process of CBT development. A review of literature on CBT development and a survey of over 200 developers of CBT courseware were conducted to investigate methods of measuring courseware quantity and quality. Many of the statements frequently made by survey respondents echoed the experiences of the MTP-RC program.

In summary, there is no widely endorsed method of measuring interactive courseware. Respondents stated that statements of work for interactive courseware development require more detailed descriptions of soldier performance objectives and desired training features than do statements for development of traditional training. Various measures, such as instructional hours, objectives, and number of interactions, are in use, but all have limitations. To overcome some of the difficulties of specifying courseware procurements, it was recommended that the possibility of phased procurements be studied. In a phased procurement, the training analysis and some design would be done as a first, separate phase of the work. With the results of the training analysis, it would be possible to more clearly specify the desired soldier outcomes, presentation features, and amount of courseware needed. With this information, both the Government and contractors could be more confident in the estimates of time and cost for development, and could avoid some of the renegotiation of scope that developers reported as common.

Enhancements to the Systems Approach to Training can be helpful in defining the design standards for a CBT development project. Issues such as visual fidelity in simulations, student passing criteria, types of visual images need to be decided differently for interactive CBT than for shop training, videotape, or other linear presentation media. For large CBT development projects, it can be helpful to make design decisions on a course-wide basis and apply them for individual lessons with the use of templates, which are computer programs written to implement instructional strategies. If generic objectives can be developed, templates can assure uniform application of design decisions across all lessons of the generic type. Although there are some difficulties with designing and reviewing templates, the ability to implement sophisticated strategies in many lessons with templates can increase the effectiveness of the courseware.

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