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Technical Report 713

An Enhanced Instructional Design Process for Developing Interactive Courseware

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U. S. Army
Research Institute for the Behavioral and Social Sciences

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

This report contains a description of the design process developed to create interactive computer-based courseware for the Model Training Program for Reserve Component Units (MTP-RC). The first part of the report describes the limitations of the standard Systems Approach to Training (SAT) process when applied to the design of the highly interactive computer-based training (CBT) and the reasons why the design team sought to increase the efficiency of the process. The second and major part of the report describes the design processes that were developed and added to the SAT model and (Continued)

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how they were used to create MTP-RC courseware. The major enhancements to SAT were (a) the use of analysis and design procedures focused at the course level, (b) the development and use of decision-making guidelines to aid the selection of content and the selection of instructional strategies, and (c) the application of software engineering techniques to CBT.

The application of these design tools can aid other instructional designers in creating computer-based training courseware more efficiently.

Technical Report 713

An Enhanced Instructional Design Process for Developing Interactive Courseware

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FOREWORD

Training support limitations in the areas of personnel, equipment availability, and operational costs are necessitating the incorporation of technology-based training into the Army system. The Army Research Institute Fort Knox Field Unit is attempting to facilitate this transition with the research and development of computer-based maintenance training initially targeted for the Reserve Component. The Model Training Program for Reserve Component Units includes 200 hours of maintenance training and relies heavily on two-dimensional simulation to train soldiers to maintain the M1 tank which may not be physically present at the Reserve training site.

As large-scale computer-based training programs are beginning to be developed by the Army, continuing emphasis must be placed on the refinement of training development models which maximize the capabilities of these new technologies. This paper describes an innovative instructional design process developed to enhance training effectiveness and production efficiency. The model increases the efficiency of large-scale instruction design by the use of instructional templates, as well as by providing decision guidelines for selecting content and instructional strategies. This approach is believed to have resulted in a production time savings of 25% over more conventional approaches.

EDGAR M. JOHNSON
Technical Director

AN ENHANCED INSTRUCTIONAL DESIGN PROCESS FOR DEVELOPING INTERACTIVE COURSEWARE

EXECUTIVE SUMMARY

Requirement:

The Model Training Program for the Reserve Component Units (MTP-RC) is a research project conceived by the U.S. Army Research Institute (ARI) and the Training and Doctrine Command (TRADOC) Training Technology Agency to develop and validate an effective computer-based instructional response to the training challenges created by the introduction of new equipment into the Army inventory. The purpose of this report is to describe the instructional technology developed and used to create approximately 200 hours of interactive courseware to train soldiers in four Military Occupation Specialities (MOS) to maintain the M1 Abrams tank.

Procedure:

The first part of the report describes the limitations of the standard Systems Approach to Training (SAT) process when applied to the design of highly interactive computer-based training (CBT). The second and major part of the report describes the procedures added to the SAT model and how they were used to design MTP-RC courseware. The major enhancements include (a) the use of analysis and design procedures focused at the course level, (b) the development and use of decision-making guidelines to aid the selection of content and the selection of instructional strategies, and (c) the application of software engineering techniques to CBT. The resulting design process that includes all these components is MacroDesign.

Findings:

The authors report that MacroDesign provides instructional designers with tools and techniques for use with nonlinear instructional media. The use of MacroDesign

1. Provides instructional designers with decision-making guidelines to systematically aid content selection when it is not feasible to develop all the possible cortent.

2. Aids instructional designers in identifying similar skills and behaviors within the selected body of content.

3. Provides decision-making guidelines for the selection of appropriate instructional strategies.

4. Separates the design of content and screen displays from the design of program logic, thus providing a clear description of the structure and organization of the computer-based lesson.

5. Facilitates efficient communication of lesson design, including both content and logic, to other designers, subject matter experts, and courseware developers.

6. Facilitates the cost-effective allocation of design and development tasks among members of the labor pool. The result is that experienced, senior designers and courseware developers create the high level designs and codes, and the junior designers and courseware developers develop and code the lesson content.

Utilization of Findings:

The application of the instructional technology described in this report will assist other instructional designers to increase the design efficiency of nonlinear instruction. The decision-making guidelines, although not exhaustive, help assure that instructional designers consider important issues. The design tools and techniques described can be applied to the design of computer-based training including those systems which include interactive videodisc.

AN ENHANCED INSTRUCTIONAL DESIGN PROCESS FOR DEVELOPING INTERACTIVE COURSEWARE

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OVERVIEW OF REPORT

The Model Training Program for Reserve Component Units (MTP-RC) was conceived by the US Army Research Institute (ARI) and the Training and Doctrine Command (TRADOC) Training Technology Agency as a research and development program. MTP-RC was designed to develop and validate an effective computer-based training program that would use educational technology to address the training needs of the Reserve Component (RC) units. Instruction was designed to train and sustain troubleshooting and maintenance skills in four Military Occupation Specialties (MOSs) associated with the M1 Abrams tank. This training was designed specially for RC units that lack equipment or experienced instructors for traditional training on new equipment. Approximately 200 hours of computer-based training (CBT) courseware were developed for this program. The MTP-RC courseware is highly interactive computer-based training that makes use of high-resolution graphics and randomly accessed videodisc images.

The purpose of this report is to provide information about the instructional technology used to produce MTP-RC courseware so that other instructional designers can transfer the technology to their own applications. This report contains the following: a description of the steps in the MTP-RC design process, explanations why these steps were performed, and assessments of their value in the design process. The instructional technology described in this report may aid instructional designers (IDs) to produce sophisticated CBT more efficiently.

The report is divided into two parts:

1. The need for enhanced design models.

2. The enhanced design model developed and used in MTP-RC.

The first part presents the challenges that MTP-RC designers faced and describes the components of the Systems Approach to Training (SAT) model which they sought to enhance. In the second part, the technology used to design MTP-RC courseware is presented and each step in the process is described. Examples are provided that illustrate the use of decision-making guidelines during the instructional design process, the application of analysis and design at the course level, and the use of techniques from the field of Courseware Engineering.

THE NEED FOR ENHANCED DESIGN MODELS

Background

MTP-RC required the design and production of approximately 200 hours of state-of-the-art interactive courseware in a relatively short period of time. Much of this training required the simulation of sophisticated electro-mechanical equipment. The MTP-RC design team recognized that if success were to be achieved, the courseware design and development technology would have to facilitate extremely rapid and efficient design, provide maximum guidance to designers, and provide for precise communication among everyone involved in the design and development process. This represented a substantial challenge to the design team.

The design team was committed to using the Systems Approach to Training model of designing instruction, but was concerned about some of SAT's restrictions. For example, Allessi and Trollip (1985), writing about the related Instructional Systems Development (ISD) model, state that:

> ...although ISD provides a comprehensive approach to curriculum design for standard media, it lacks sufficient detail at the level of individual lesson development; and as currently formulated it gives no guidance in getting a lesson, once designed, into and working on a computer. Finally, ISD provides little guidance regarding the more creative uses of the computer, such as simulations and games.

The design team was concerned that using the SAT model, in its current form, would hinder rapid and efficient design of a large body of highly interactive courseware that would include a substantial amount of computer simulations. Specifically, they wished to enhance the design model so that it could:

1. Aid the design team in identifying similar skills and behaviors in order to create instructional designs that could be applied to all lessons containing similar skills and behaviors.

2. Provide decision-making guidelines that could aid in the selection of content when it is not feasible to develop lessons for all the possible content, and to provide decision-making guidelines that could aid the selection of appropriate instructional strategies.

3. Provide design tools and techniques specifically for use with non-linear instructional media that would make communication of lesson content and program logic more efficient.

Each of these goals will be discussed in more detail in the next section of this report.

Lesson Level Design

Instructional designers are familiar with traditional methods of systematically designing instruction. In the SAT model, analysis and design are done in stages (Andrews & Goodson, 1980). In these stages, attention is focused successively from the curriculum level to the course level and focuses, in the end, on the lesson level. At the curriculum level, needs are assessed, goals are established, and the course sequence and structure are determined. Then course objectives are established. Work then begins at the lesson level with the definition of performance objectives.

When instructional designers develop large blocks of instruction, they typically begin designing the first lesson once the task analysis has been completed. The designer usually follows design steps such as those described by Gagne and Briggs (1979), and Dick and Cary (1985). When this design approach is used for courses composed of many lessons, instructional designers usually repeat the steps for each lesson until the course is completed. This design approach, which iterates only at the level of lesson design, is inefficient because of the large number of steps required to design all the lessons. Because the MTP-RC courseware would be composed of over one hundred lessons, the design team sought ways to enhance the SAT model to increase the efficiency of lesson level design.

Decision-Making Guidelines

Instructional design is, at its most basic level, a decision-making process. Instructional designers select a particular instructional design or strategy on the basis of several factors. The quality and effectiveness of a specific design directly reflects the skill with which the decisions were made. Inexperienced designers often are unable to make the correct decisions, and, as a result, instructional quality can suffer.

Instructional design models list the sequence of general steps to follow to create a design, but most design models do not explain how to actually perform the activities required within the listed step. As a result, little guidance is provided for making informed decisions. Without such guidance, designers rely on their personal experience. For example, when designers must narrow the range of content for which instruction can be developed, it is often very difficult to determine effectively which content to include. The absence of guidelines contributes to the inexperienced designer's inability to weigh the importance of competing content. Consequently, later in the design process, designers discover that they need to add or delete content and this requires additional time and increases cost.

The lack of models also extends to the selection of instructional strategies. For example, when a designer is working with a medium that can display visuals ranging in fidelity from a cartoon to an enhanced video image, how is the designer to select the most appropriate form to accompany instruction of a difficult task? Few guidelines exist to aid his decision. When design models do not provide guidance, the designer must rely on experience, intuition, luck, and some research. Unfortunately, this combination is often insufficient. For these reasons, the MTP-RC design team sought to establish decision-making guidelines that could aid a designer in the selection of content for development and in the design of appropriate instructional strategies.

Design and Communication Tools for Non-linear Media

Instructional designers (IDs) employ design tools as they create instruction. Design tools include the steps, processes, and guidelines that provide the instructional designer with a way of making informed decisions during the design process. Today, most of the tools available to designers were created when instruction was delivered on linear, non-branching media, such as instructional television programs. In linear programs, the learner follows the one path through the instruction laid out by the designer. With the advent of computer-based training, more complex branching became possible. Consequently, the number of paths a learner can take through instructional material expanded considerably. In computer-based training programs that include branching, the path taken depends upon the learner's responses. Consequently, instruction with multiple branching is called non-linear instruction.

Few design tools have become available for designing instruction for computer-based, non-linear media. The MTP-RC design team sought ways to create new design tools that could be used to increase the efficiency of designing non-linear instruction and remove the constraints of using tools intended for linear media. As the discipline of instructional design continues to evolve, the number of design tools will expand. As these instructional design tools become available, designers must seek ways to implement them, that is to say, transfer the educational technology to other applications.

The tools used to create instruction define the way the designer communicates lesson designs to other members of the design team. The design of non-linear instruction requires that instructional designers communicate information about both the lesson's content and branching logic for the computer program. Communicating the branching logic to members of the design and production teams can become quite complicated as the number of possible interactions per screen increases in number and complexity. In a highly interactive design, virtually every display offers the student numerous options; not only can students select the right or wrong answer to a question, but they can press special function keys, spell a word incorrectly, use incorrect capitalization, or not enter a response at all. Designers must design responses for every conceivable student input and clearly communicate the complex design to other instructional designers and to programmers.

To communicate lesson designs, instructional designers usually storyboard CBT lessons, the same as they would if they were planning a linear instructional sequence, such as a videotape. Using a storyboard formatted for the CBT system being used, designers write or type in the text that is to appear on the display and sketch or describe any graphics that are to be used. Designers also provide detailed branching instructions for any anticipated student input. Each storyboard then contains two kinds of information: lesson content and branching logic.

Although storyboards contain descriptions of lesson content and branching logic, the person reading the storyboards must try to follow both descriptions simultaneously while seeing but one screen display at a time. This narrow view makes it difficult for the reviewer to get a sense of the lesson as a whole. For content, the display-by-display approach is acceptable, but not ideal. For program logic, however, it is unacceptably awkward because a program is not a series of individual displays, but rather, a set of hierarchically related functions, any one of which might be called at any time.

Specifying logic only at the display level can lead to two problems. First, it may require programmers to spend inordinate amounts of time attempting to infer the higher level structure and organization of the lessons and programs. For example, if a designer repeatedly used similar strategies for handling similar interactions throughout a program, but described the interactions differently, discerning the pattern would be unecessarily difficult for the programmer. The programmers must separate the branching logic from the content and attempt to discern a pattern in the sequence of individual screen displays. If they discern a consistent pattern, they must determine what the rule is that describes the pattern. Second, this method of specifying logic is fragmented and causes inefficiencies in coding. For example, if the programmers could not discern and discuss a recurring pattern within the storyboard, they would needlessly rewrite the code each time the recurring interaction appeared in the program. In addition to the waste of human resources, the failure to identify and communicate subroutines to handle recurring interactions leads to increased amounts of code, which in turn makes it more difficult to debug the courseware. For these reasons, the MTP-RC design team sought ways to communicate content and program logic more efficiently than the storyboard method permits.

The next section of the report contains a description of the design process used to produce MTP-RC courseware. The descriptions of each step will include the enhancements made to the SAT model. The enhancements included methods to:

1. Increase the efficiency of designing instruction on a large scale.

2. Provide decision-making guidelines for selecting content and for selecting instructional strategies.

3. Increase the efficiency of communicating content and program logic to members of the design and production teams.

THE ENHANCED DESIGN MODEL USED IN MTP-RC

Overview

The MTP-RC design team was composed of the project manager, the senior instructional designer (ID), the senior courseware developer (CD), the subject matter experts (SMEs), junior instructional designers, and junior courseware developers. The design team faced the challenge of developing a large amount of state-of-the-art courseware for the MTP-RC. Having identified the needed enhancements they wished to make to the standard SAT model, the design team sequenced the required enhancements according to their chronological use in the design process. Specifically, decisions associated with the following design activities were to be made:

1. Content selection guidelines - MTP-RC program constraints dictated that only a selected subset of the content domain could be developed. What criteria could be used to wisely select this content subset?

2. Program level lesson design - Following the selection of the content subset, a substantial amount of content would be developed for CBT. What design and development strategies could be used to identify common performance requirements within the content?

3. Instructional strategy selection guidelines - Once common performance requirements were identified within the content subset, instructional material for each learning objective had to be produced. What guidelines could be used to assure that appropriate instructional techniques would be used for each objective?

4. Improved communications - No efficient techniques existed for communicating CBT instructional designs to other designers or to programmers. What design tools could be developed to improve the communications among members of the design team and with programmers?

The analysis of these problems led the design team to develop supplementary steps to the standard SAT design process. The design model which evolved and which is still evolving has been named MacroDesign. The steps included within MacroDesign are supplementary to those included within the standard SAT model. It is called MacroDesign because it involves the application of design tools and techniques at the course or "macro" level as well as to the lesson level. MacroDesign utilizes Courseware Engineering, which is the application of software engineering techniques to CBT. Courseware Engineering facilitates the design of lesson templates which are ways of describing instruction for lessons which share similar skills and behaviors.

The process used to design MTP-RC instruction began with content selection and proceeded through task analysis to lesson design. A major difference between the SAT approach and this enhanced approach is that, from the very early stages of the process, beginning with task analysis, the enhanced design model provides a structure which helps the design team focus their attention upon the commonalities within the course content. Identifying similar skills and behaviors within a body of content can eliminate the unnecessary duplication of effort required by designing at the lesson level. This approach also promotes consistency among lesson designs and results in a user interface which is consistent among lessons.

The main objective of this approach was the development of instructional templates. "Templates" are generic design strategies that are used for a subset of the tasks being trained. The design of instructional templates utilizes Courseware Engineering, which separates content description from logic specification (Stacy, 1984). This separation facilitates the identification and development of coding subroutines for instructional interactions which will be used repeatedly in the course. Instead of requiring the designer to develop storyboards or screen design pages describing both the content and the logic design of a lesson, Courseware Engineering allows these to be described separately. Templates describe the instructional strategies to be employed, including the interactions that will occur within a lesson. For the designers it is a descriptive model for designing each lesson; for the programmers it is a descriptive model for program logic. The use of templates facilitates communication between instructional designers and programmers.

The design of these templates is guided by the designer's consideration of environmental factors and other guidelines that affect the designs. The resulting templates then are used to develop subsequent lessons. This process of designing templates for instructional components that share similar enabling objectives is a major component of MacroDesign.

The discussions in this report are restricted to descriptions of the steps included in the analysis and design phases of MTP-RC courseware. This report does not include descriptions of the courseware production phases. For a discussion of the production phases see Begg and Bernstein (1985). The following sections of the report will describe MacroDesign processes. MacroDesign began with content selection, continued through to the development of content and coding of the prototype lesson. The order of the processes was:

1. Content Selection.

2. Task Analysis and Training Task Analysis.

3. Template Design.

4. Prototype Development.

Decision-making guidelines were among the design tools used in MacroDesign. The guidelines were used to aid instructional designers make content selection decisions and to aid the selection of instructional strategies within the template design process. The next section of the report describes the content selection process and the use of decision-making guidelines during the process.

Content Selection

Environmental Factors

The MTP-RC design team wished to incorporate into the design model guidelines that could be used to aid content selection decisions. During the formulation of the MacroDesign model, the design team identified a series of questions the instructional designers should consider before making content selection decisions. These questions were clustered into groups and categorized by the environmental factor that affect these decisions. After a careful analysis, four distinct spheres of influence emerged:

1. The institution that is sponsoring the training development activity.

2. The audience for which the training is being developed.

3. The content being trained.

4. The resources that are available to support the development effort.

The four factors identified are not exhaustive, but they were the factors considered during the MTP-RC content selection process. The factors were not assigned weighting values. A pragmatic approach was taken acknowledging the primacy of the sponsoring institutions' requirements over the other factors. Although the discussion will address each factor in turn, during the actual content selection process the questions contained within each factor were considered several times. Therefore, the listing of the factors is not intended to imply a strict procedural order, instead the factors are identified as a means of assuring that all the appropriate questions were considered. Listed below are typical question which guided instructional designers' content selection decisions.

INSTITUTION: Where will the training take place?
How often will it be given?
Who will deliver the training?
What factors led the institution to develop the training at this time?

AUDIENCE:	Who will be taking the training? What do they already know? How long have they known it? How motivated are they to learn? How familiar are they with the training medium?
CONTENT:	How critical is the task? How stable is the task? How frequently will the task be encountered? Will a selected task allow transfer of a skill to an unselected task?
RESOURCES:	How much time is available for training? How much development time is available? What are the budgetary constraints? What equipment is available during training? Are subject matter experts available, and if so for how long and at what cost?

Some of these questions do not fit neatly into one factor. For example, the question about who will take the training is listed under the Audience factor, but in the case of MTP-RC the sponsoring institution made this decision. The question about how frequently a task must be performed is listed under Content, but it also could have been listed under Audience. The precision with which the questions are categorized is not critical. The major concerns are providing some guidelines to instructional designers for deciding which content should be included and which content should be excluded from the next step in the design process.

Consideration of the four environmental factors assisted instructional designers in the content selection process. How each of the four environmental factors affected content selection is discussed in turn in the hope that the discussion may be useful to others when they design instruction.

Figure 1 is a flowchart of the content selection process and shows in detail some of the steps contained within Figure 2, Step 1. Figure 1 presents an illustration of how each environmental factor yielded a new content subset within the selection process. Each environmental factor is discussed below. Figure 2 presents a flow chart with the major steps of the enhanced design model used in MTP-RC courseware development.

Institution. Selecting content for MTP-RC was largely decided by the institutional requirements of the Army Research Institute and the U.S. Army Ordnance Center and School. These two institutions, using their own criteria, had analyzed the need for training, had selected the target audience, and had selected from among the entire domain of MOS tasks a subset of critical tasks for inclusion in the course. The design team asked the institution questions for the purpose of clarifying the

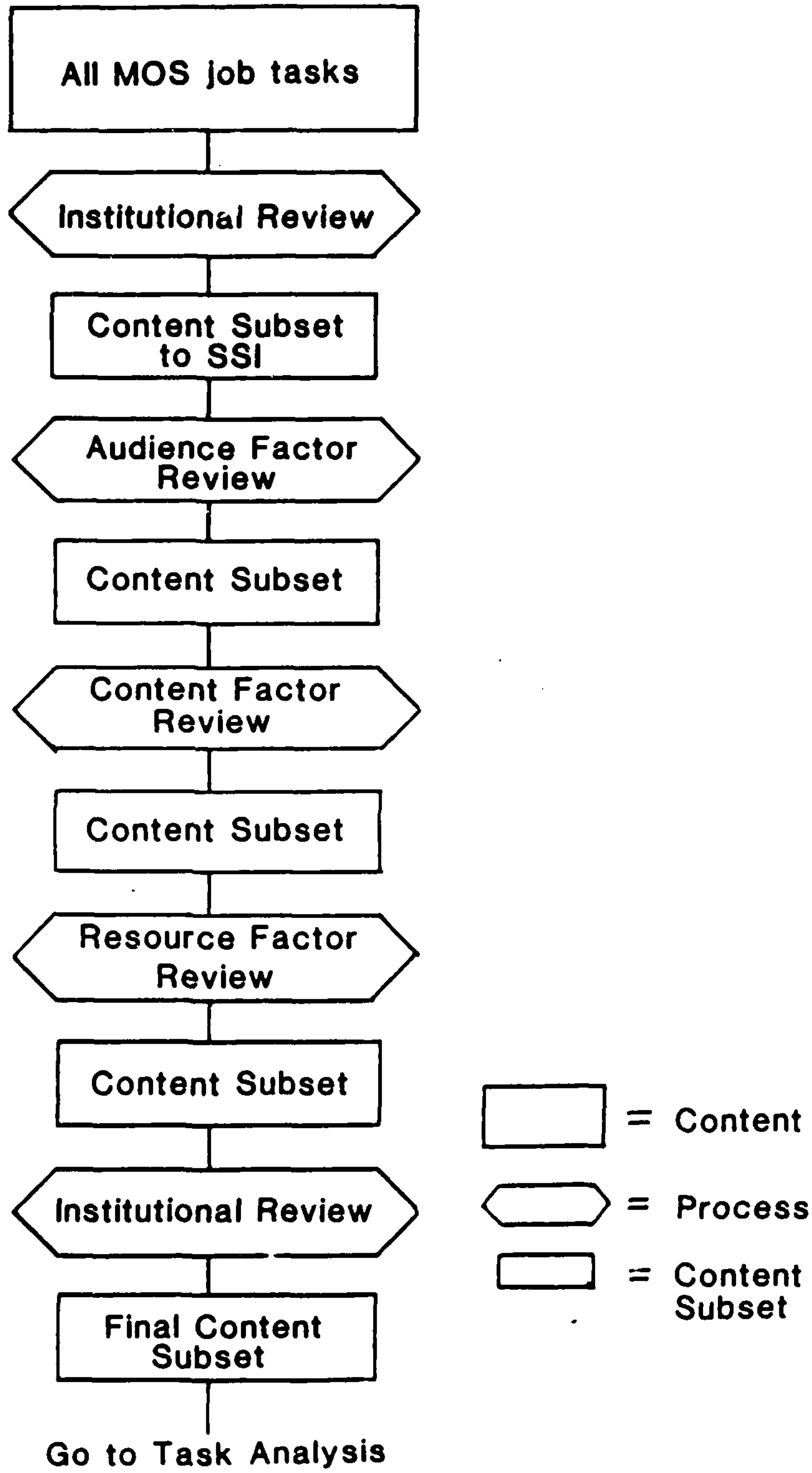

Figure 1. Content selection process of task analysis.

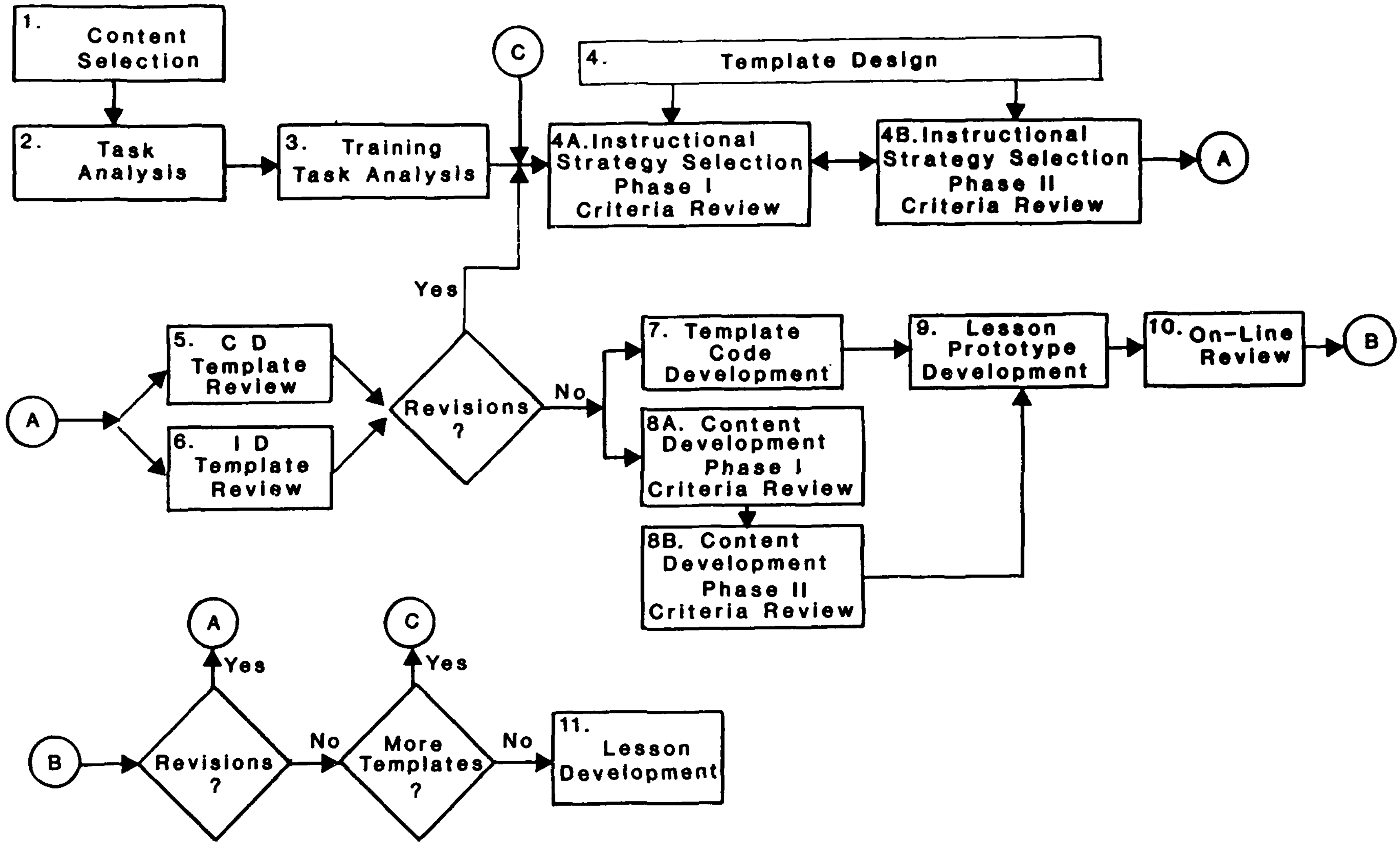

Figure 2. Major steps of the enhanced design model of MTP-RC.

institutions's needs. The answers to these questions proved critical to subsequent stages in the analysis and design stages. Of equal importance was the fact that the sponsoring institutions already had identified the subset of MOS tasks that reflected their priorities. Consequently, the institutions's decisions narrowed the amount of content that the design team had to analyze.

Audience. Once the design team received the list of tasks from ARI and the Ordnance School, the design team reviewed the list in light of the other three factors. The design team considered what task-related knowledge the soldiers already possessed and how well they knew it. As a result of this review, the design team identified: (a) the tasks in which soldiers already had received instruction, and (b) the subset of those tasks in which soldiers required additional practice to enhance their retention of the skills. Considering the institutions's requirement that skill areas common to M1 MOSs be given priority, the design team selected content that would require soldiers to practice a wide range of tasks and subtasks involved in the main task. For example, the design team selected the use of STE-M1/FVS and Breakout Box test equipment. The design team believed that the development of these skills would be improved by including them within the MTP-RC program with the intention of requiring their extensive practice.

An institutional priority linked to audience was the decision to develop training that would be effective for training overlapping MOS pairs. Therefore, the design team identified specific tasks that had to be included in order to achieve this priority. The tasks selected for this audience had to include tasks that would coordinate and differentiate tasks within an MOS pair. For example, on the M1 tank DS/GS (63H) mechanics often repeat the diagnostic tests performed by organizational personnel (63E) that sent the tank line replaceable unit (LRU) or component for higher level maintenance. Subject Matter Experts working with the design team selected tasks within a MOS pair that would simulate the flow of work and differentiation of tasks in real life. After selecting content considering audience factors, the resulting content subset was reviewed considering the the content itself.

Content. Once the design team had selected content for the target audience, they focused their attention on prioritizing the content according to its degree of field utility because resources would not permit the design and development of all the tasks in the existing content subset. The criterion for selecting the tasks for inclusion in MTP-RC were those that were identified as having high field utility. High field utility included four factors. First, tasks were selected that were on the Training and Doctrine Command (TRADOC) critical tasks list. Second, tasks were selected if the diagnostic procedure or corrective action was thought to be stable - i.e., it was unlikely to change a great deal as the evolving M1 system and the M1 Technical Manuals (TMs) change. Third, the SMEs selected line replaceable units and components that, in their experience, were likely to have higher failure rates in the field, such as the hull networks box and alternator. Fourth, the design team selected tasks that would give the soldiers experience with as many LRUs as possible and allow maximum transfer of skills to tasks not selected, given the training time and development resources of the program. For example, when a 63H soldier has been trained to perform a STE-M1/FVS engine power check (a selected task), many of those skills will probably transfer to performing a STE-M1 engine abort test (a task not selected).

Resources. Since resources always are limited, it is a powerful environmental factor that affects content selection decisions. Having ranked the field utility of the content, the design team focused their attention on determining how resource factors would limit the amount and kind of content that could be selected for courseware development. Among the key points they considered were: the number of instructional hours required, the amount of development time available to produce the instruction, budgetary constraints, and the availability and expense of resources such as SMEs, video production personnel and facilities. Because MTP-RC is a model training program, the design team also selected content to allow the demonstration and evaluation of such CBT capabilities as simulation, gaming and instructional management. Considering these resource issues, the design team narrowed the content subset even further. The resulting subset was submitted to the sponsoring institutions for their review and comments. The design team considered the institutions's recommendations and made the final selection of content based on those recommendations.

The content selection process the design team used incorporated the needs and requirements of the institution, the needs of the target audience, the priority of the content, and the limitations and demands imposed by limited resources. These factors are not weighted, however they are useful in that they assure that their influence on content selection will be systematically and consistently considered. Once MTP-RC content was selected using these guiding factors, the design team began the next step in the design process, task analysis.

Task Analysis and Training Task Analysis

The reader is advised to follow the discussion of task analysis and training task analysis by referring to Figures 2, 3 and 4. Figure 2 is a flowchart of the analysis, design and develpment steps used in MTP-RC. Figure 3 is an illustration of the relationship of the work performed by the instructional design team and the work performed by the programming team during the various stages of MacroDesign, including training task analysis. In Figure 3, vertically overlapping circles indicate iteration or revisions between stages of the MacroDesign process. Horizontally overlapping circles indicate communications between designers and programmers. Figure 4 presents a list of the processes in macrodesign with emphasis on training task analysis and template design.

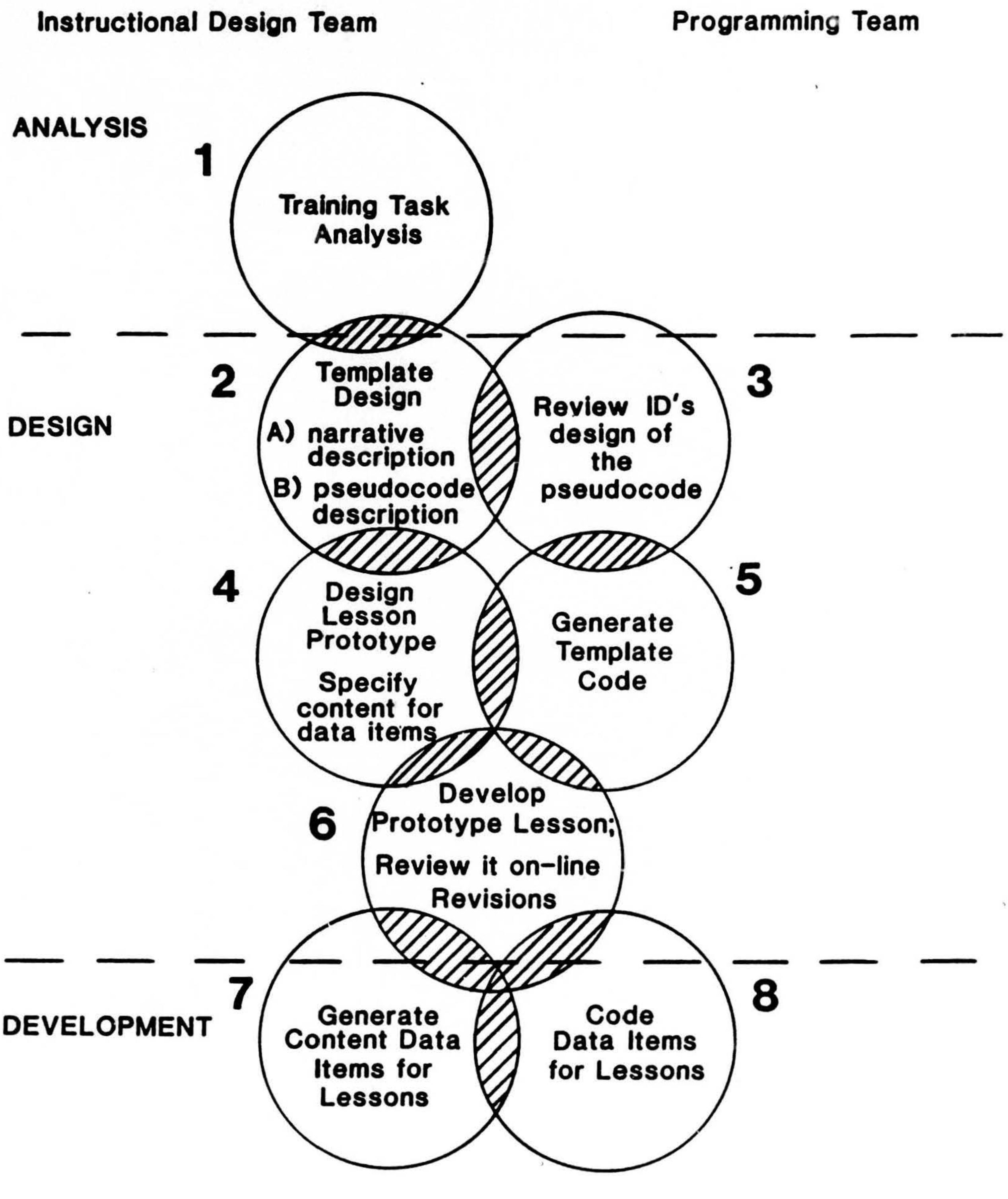

Figure 3. Analysis, development, and design process.

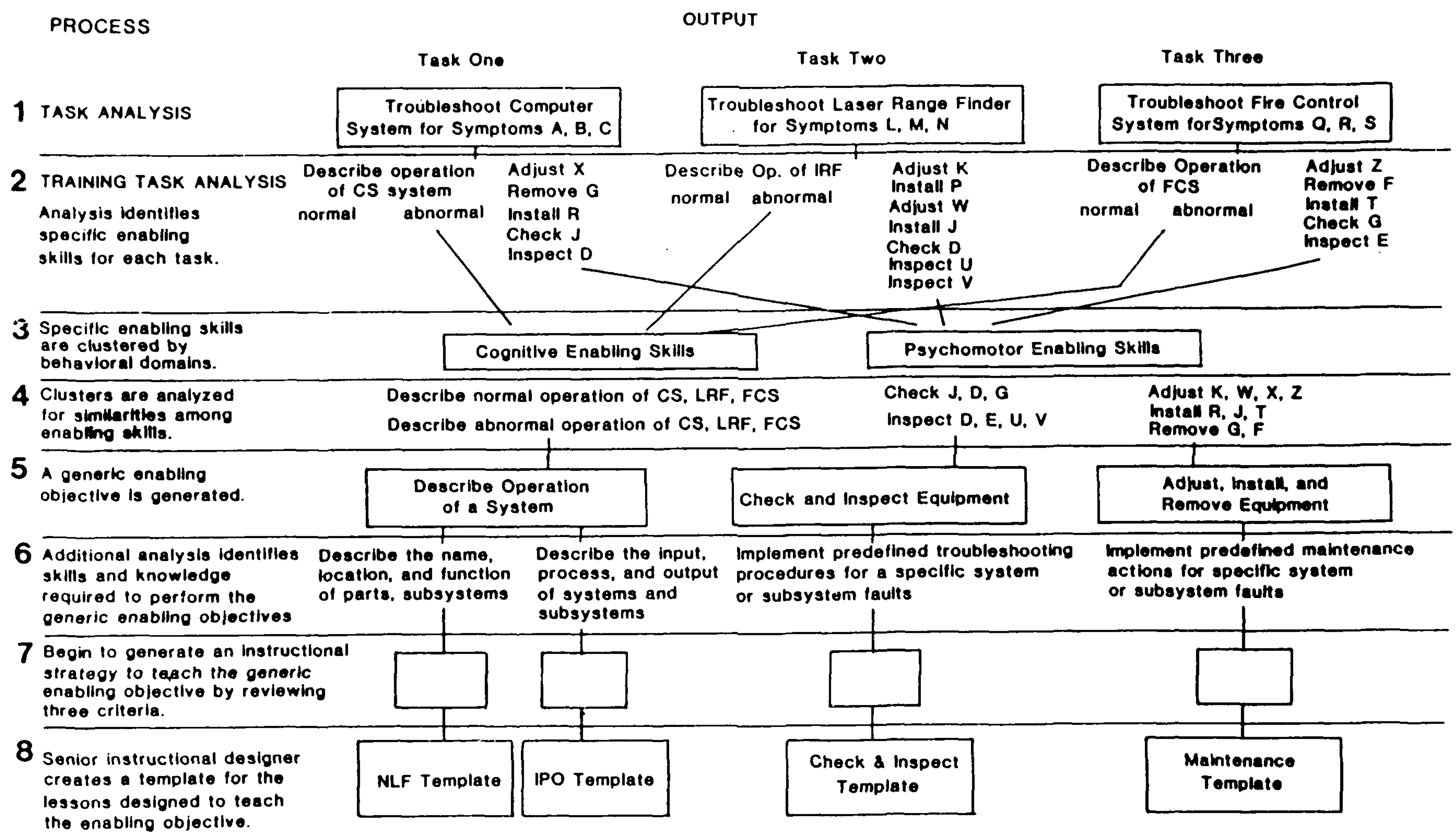

Figure 4. Processes of macrodesign.

Task Analysis

The main objective of MacroDesign is to apply design tools and techniques at the course or macro level. This design method is more efficient than the standard SAT model because it eliminates the duplication of procedures inherent in lesson level design processes. The identification of similar skills and behaviors eventually leads to the creation of a generic instructional design that serves as a template for the creation of all lessons sharing those similar skills and behaviors. For these reasons, a critical task in MacroDesign is the identification of similar skills and behaviors within the subset of content selected for development. Similar skills and behaviors are identified through the related processes of task analysis and training task analysis.

The term "task analysis" has become a generic label used by a wide assortment of engineers, equipment designers, human factors specialists, technical publication writers, and training developers to describe a systematic approach to the collection and analysis of job related task elements. The MTP-RC design team task analyzed the final content subset and identified the high level behavioral objectives for the course (Figure 4, Step 1). Specifically, the design team analyzed the content with the goal of identifying the tasks that the four MOSs perform to troubleshoot and maintain M1 hull and turret systems for specific sets of fault symptoms. The task analysis conducted by the design team identified the steps required to perform these troubleshooting and maintenance tasks. The design team then subjected the resulting list of tasks to training task analysis.

Training Task Analysis

Training task analysis is qualitatively different from task analysis. Training task analysis involves analyzing jobs into their component subtasks and identifying the skills and knowledge required to support task performance (Figure 2, Step 3). The skills and knowledge necessary to perform the subtasks are described as enabling behaviors, and the goals of lessons designed to teach these behaviors are described in enabling objectives. As described by Eschenbrenner, DeVries, Miller, and Ruck (1979), the output of a training task analysis can be thought of as a specification that defines the content of an instructional program. This specification results from instructional designers and subject matter experts combining their expertise to identify the major procedural steps within a task and make inferences about required skills and knowledge.

The task analysis conducted by the design team resulted in lists of skills or tasks for which instruction was required. An example of such a task within the MTP-RC content was the task of troubleshooting the M1 tank's computer system for a specific set of symptoms (Figure 4, Step 1). The goal of the training task analysis was to construct task hierarchies which broke down the main tasks into their enabling behaviors, that is, the skills and knowledge needed to perform the major task. The subject matter experts and instructional designers collaborated to conduct the training task analysis and thus identified the training requirements for each selected task. They analyzed each major task into a hierarchy of procedural steps and task elements in order to identify the skills and knowledge to include in the training program. For example, the task hierarchy for troubleshooting the computer system (CS) of the M1 tank consisted of the following enabling behaviors (Figure 4, Step 2):

1. Describe the normal operation of the computer system.

2. Describe the abnormal operation of the computer system.

3. Check and inspect a variety of parts and subsystems.

4. Adjust, remove, and install a variety of parts and subsystems.

After the SMEs and IDs categorized each major task into task hierarchies, they examined the lists of enabling skills and knowledge to identify any underlying similarities (Figure 4, Step 3). This process required the design team to group specific enabling skills by behavioral domains. In MTP-RC for example, the enabling skills of describing the normal and abnormal operations of the computer system, the laser range finder, the fire control system, etc., are all examples of behaviors within the cognitive domain. The enabling skills of adjusting, inspecting, checking and installing subsystems of the computer system, laser range finder, and fire control system, etc., are all examples of behaviors within the psychomotor domain.

Having grouped the enabling skills by behavioral domains, the design team analyzed the enabling skills in each domain to identify similarities among them. For example, the design team was able to sort all the cognitive skills into two clusters. One cluster contained all those skills which required descriptions of normal operations of systems. The second cluster contained all those skills which required descriptions of abnormal operations of systems. The clustered cognitive enabling skills each require the trainee's knowledge of the operation of the system being diagnosed and how a malfunction affects operation of the system. This knowledge provides a framework for performing the tasks and is the basis for continued development of advanced troubleshooting skills.

The clustered psychomotor enabling skills required the performance of either check/inspect skills, or the performance of maintenance action skills. The check/inspect tasks are the tests, inspections, measurements, etc., that the soldier must perform to determine which component or part is faulty. These skills include visual inspections, electrical tests, mechanical checks, leak checks, etc., that give the yes or no answers required in the M1 Simplified Performacne Aids (SPAs) Technical Manual troubleshooting procedure. Maintenance actions are generally the type of tasks performed to correct malfunctions, such as replacing a part, lubricating parts, removing a guard, using special lifting devices. However, in many cases, several maintenance actions are required to perform the check/inspect tasks. Maintenance actions vary in complexity and one complex task may be a subtask for another task. Complex subtasks were themselves analyzed into their component tasks to a level that clearly defined the need for an instructional segment.

Each cluster of enabling skills within a behavioral domain defined a need for a component of instruction, such as a lesson. The design team next focused their attention on generating an objective which would be applicable to all the enabling skills within a cluster. The term given to this inclusive objective is "generic enabling objective." It is called generic because it is descriptive of a type of objective applicable to more than one lesson. For example, the generic objective, "describe abnormal operation of system", encompasses the enabling objectives developed for several lessons - describe abnormal operation of laser range finder, describe abnormal operation of computer system, etc. (Figure 4, Step 5). The creation of generic enabling objectives was a key action within the design of MTP-RC instruction, for it was this act of identifying similarities among the skills and behaviors within related clusters of enabling skills that eventually permitted template design.

Training task analysis did not cease after the generation of generic enabling objectives. These objectives were themselves analyzed by the design team to determine what skills and knowledge a soldier would need to perform them (Figure 4, Step 6). In MTP-RC, for example, instructional designers determined that the generic enabling objective, "describe the operation of a system" required that the soldier be able to perform several different skills. First, he must be able to identify the name, the function, and the functional location of a tank component or system. And second, he must be able to identify the input, process, and output of a tank component or system.

Once the design team had identified the skills required to support the per ormance of the generic enabling objectives, the design team began creating templates. Templates are generic instructional strategies suitable for teaching each of the supporting skills (Figure 4, Step 7). The design team's selection of appropriate instructional strategies was aided by decision-making guidelines. How the decision-making guidelines affected the design of templates will be discussed in the next section of the report.

Template Design Issues

A template is a detailed description of both the instructional strategies that will be used and the interactions which will occur within a lesson. Once the design team identified the subskills needed for performance of the generic enabling objectives, they began to design instructional strategies to develop the required skills. The design team's selection of appropriate instructional strategies was guided by the use of decision-making guidelines.

Decision-Making Guidelines

Early in the project, the design team had been concerned that sufficient guidelines did not exist to aid the selection of specific instructional strategies. In response, they established decision-making guidelines to use during the template design process (Figure 2, Step 4). The design team systematically considered these decision-making guidelines when selecting an instructional technique for a given generic enabling objective. In retrospect, they found that other guidelines may be helpful. Therefore, the guidelines described in this report should not be considered exhaustive. The guidelines which were considered in MTP-RC aided the selection of: feedback, passing level, learner control, visual fidelity, simulation fidelity, performance error fidelity, and level of guidance. Each set of guidelines includes advice that describes how environmental factors affect the selection of instructional strategies. The environmental factors are the same as those first considered in the content selection process: audience, institution, content, and resources.

These guidelines are not absolute in nature, but are reviewed by the instructional designers to ensure that informed selections are made. As was true with the environmental factors, the decision-making guidelines for selecting appropriate instructional strategies are not weighted. Occasionally this resulted in crossed situations when, for example, when the institutional consideration was in conflict with the audience consideration. On these occasions, if the conflict was serious, the design team typically resolved the conflict by discussing it with the sponsoring institution.

As was the case with the environmental factors, these guidelines are not meant to be employed in a rigid manner. The guidelines were not intended to be used as if they were scientific quantities, rather they were introduced into the design process to assure that instructional decisions would be considered deliberately and carefully by the design team at the appropriate time in the design process. Appendix A presents the guidelines in more detail.

The design team considered the guidelines at different times during the design process. Some were considered during the early stages of design, others later during the design of individual lessons. Thus, the decision-making guidelines were employed at the course, template, and lesson levels of courseware design. In the early stage of design, once initial instructional strategies for a generic enabling objective had been identified, each strategy was subjected to a two phase review process (Figure 2, Steps 4a and 4b).

In the first phase, instructional designers considered the guidelines associated with feedback, level of control, passing levels, simulation fidelity, performance error fidelity, and level of guidance as they were affected by institutional and resource factors. In the second phase, instructional designers reviewed the same guidelines, considering the audience and content factors. The reason for conducting this review in these two phases was that the constraints imposed by the institution and the available resources frequently had considerably more importance than did the consideration of the audience and content. There would have been no point, for example, in considering what passing level to use for the target audience if the institution had already decided mastery levels. The design team began their review of the guidelines by considering feedback level and learner control.

Feedback Level

Feedback is the procedure used to tell a learner if his response to an instructional event, usually a practice item or test question, is right or wrong. Feedback may be in the form of speech, gesture, text or graphics. Feedback can be used to: (a) reinforce a correct response, (b) correct an incorrect response, and (c) provide additional information to specific incorrect responses. The amount of feedback that can be given can vary from simply telling the soldier if an answer is right or wrong to providing additional explanations and instruction. Simple feedback might consist of a short statement such as, " Incorrect. Try again." Comprehensive feedback explains why a response was incorrect, what the correct answer is and why it is correct. In addition, comprehensive feedback may include a restatement of key points contained in the lesson. For example, " Smooth Washer is incorrect. A smooth washer will not hold the axle in place. You should use a LOCKING WASHER. A locking washer prevents the axle from coming loose. Remember, whenever you have a rotating shaft or axle, secure the end with a Locking Washer."

After reviewing the guidelines associated with feedback, the design team decided to use limited feedback throughout the entire course. In limited feedback the soldier is told that his response was incorrect, and he is given the correct answer. Correct answers receive positive feedback. The decision to use limited feedback was based on content and resource considerations. Most of the content in the MTP-RC courseware can be classified as either verbal information or procedural steps. In MTP-RC courseware, soldiers have to learn verbal labels, verbal facts, or specific job-aided procedures. These types of learning may be responded to quite simply with limited feedback.

Another reason why limited feedback was selected for use throughout the course was conservation of resources. Providing feedback with greater detail would have required more time for IDs to write and for courseware developers to code. This would have increased costs and would have diverted resources from other design aspects of the courseware. In many cases in MTP-RC, the feedback messages are not the only source of information for the soldier. In some templates, such as Troubleshooting Simulations, the soldier also has access to help information. The soldier also may refer to technical manuals for detailed explanations about specific systems and parts.

Learner Control

In computer-based training, learner control refers to the degree to which the learner or the computer program controls the learner's path through the sequence of units, lessons, or segments of instruction. Learner control also refers to who or what controls the selection of which content to learn within a unit, lesson, or segment of instruction. When the learner is allowed to exercise total control, he decides which content to study and the sequence to learn it in. On the other hand, the instructional designer may decide to make all these decisions about sequence and content and have them implemented by the computer program. In between the extremes of total learner control and total program control is the intermediate ground in which the learner may control the content but not the sequence, or may control the sequence but not the content.

When the learner decides which units, lessons, or segments of instruction to study, but the sequence of instruction within that selection is prescribed by the program, then the level is called content control. For example, in MTP-RC the soldier may decide to study the computer system before studying the laser range finder, but once he has made that choice he is required to learn the computer system content in a prescribed path. The design team selected content control as the learner control level to be used throughout the course because this level of control was suitable for the content and because the sponsoring institution recommended this level of control. Content control was appropriate for the content because high level elements of the content were neither hierarchically nor sequentially related, but lower level elements were. This level of control was provided to the soldier because the institution also believed it to be the most appropriate level to employ, given the nature of the content.

Passing Level

Passing level is the description of the acceptable performance level. It is the measure of the soldier's mastery of the criterion of the instructional objective. Criterion standards typically range from one hundred percent to less than seventy-five percent.

In MTP-RC, the design team decided which passing level was appropriate at the template level of design, depending upon the content presented within the lesson template. The templates for Name, Locate, Function (NLF); Input, Process, Output (IPO); and Troubleshooting Introductions were designed to provide the soldier with an informational overview of specific M1 tank systems. The information they present in these lessons is intended to provide general information to orient the soldier. For these lessons, partial mastery is an acceptable passing level because the course content requires more focus on mastering the actual troubleshooting task than the cognitive background. In addition, partial mastery is appropriate for these lessons because the objectives are incidental or transitional to subsequent instruction. The Troubleshooting Simulation and Maintenance Simulation lessons require higher passing levels because the content they present must be mastered to achieve the behavioral objective. The content in these lessons must be overlearned in order for the soldier to achieve a high level of transfer from the training environment to the actual performance of the task in the field.

Simulation Fidelity

Simulation fidelity refers to the degree of similarity between the stimuli and actions taken during training and the stimuli and actions taken during the actual performance of a task. There are four main characteristics which describe simulation fidelity. Simulation fidelity is concerned with how much the simulation duplicates:

1. The appearance and feel of the real object or process.

2. The performance of all actions required to perform the process.

3. The motion, audio, or visual cues of the object or process.

4. The environment in which the tasks actually takes place.

The degree of simulation fidelity can determine how effective training will be. It also can affect how well the skills learned in the simulation will be transferred to an actual task in real field conditions.

Two levels of simulation fidelity were used in the design of MTP-RC templates. The design team selected complete task simulation for the Troubleshooting Simulation template and partial task simulation for the Maintenance Simulation template. Complete task simulations include all the actions required to perform the task in the job environment, but does not necessarily simulate the environment or feel of the task. Partial task simulations are similar to complete task simulations except steps or groups of steps have been eliminated from the simulation of the task so that the remaining steps can be emphasized during a particular stage of training.

The design team selected complete task simulation for the Troubleshooting Simulation template because the soldiers must learn to perform each step in a troubleshooting procedure exactly as it is described in a Technical Manual. One of the goals for this type of training is to teach the soldier to follow the procedures in the TMs. Therefore, the content dictated that every step be included in the instruction.

The decision to use partial task level of simulation for Maintenance Simulations was affected by resource, audience, and content considerations. The content presented in maintenance tasks detail all the steps in a maintenance procedure, but some of the steps, such as turning bolts, and removing gaskets, did not require complete task simulation. This decision was based on the sponsoring institution's assessment that the soldiers already possessed some of these skills. The design team selected partial task simulation level for the Maintenance Simulation template because the soldiers' entry level skills indicated they did not require complete task simulation.

Partial task simulation also was selected because the job tasks require the performance of many repetitious actions which can be simplified without negatively affecting the value of the simulation. For example, because soldiers already know how to remove bolts, it was unnecessary to require the soldier to simulate the removal of all 96 bolts when separating the forward engine module from the rear engine module. Requiring the soldier to perform such a repetitious task has little instructional value and the cost of simulating every step would have been prohibitive. In addition, these repetitive tasks would have led to boredom and disinterest in the courseware.

Performance Error Fidelity

Performance Error Fidelity refers to the degree to wnich the consequences of incorrect actions will be shown to the soldier during the performance of a task. Performance Error Fidelity is a special case of feedback used within simulations. When designing simulations, the instructional designer must decide what to do when an incorrect response is given. It is sometimes desirable to flag the incorrect response immediately after it is given. The result is that soldiers will never see the consequences of the incorrect response. There are other occasions when the incorrect responses can be ignored until they lead to a natural conclusion. Which type of performance error fidelity to use depends on the level of simulation fidelity and the skill of the learner. For example, if instruction was designed to test an experienced pilot's ability to use a navigational beacon while using a high fidelity flight simulator, then performance error fidelity should be realistic. That is, if the pilot makes an error he should be able to experience the consequences of the error in order to teach him to recognize that it is an error and how to rectify the error.

When selecting a level of Performance Error Fidelity, the following issues were considered.

1. Criticality of the error and how it affects the chances of achieving success.

2. Type of skill being taught. Typically, there are two basic types of skills that can be simulated: operational skills and troubleshooting/maintenance skills. Operational skills are further categorized depending upon whether they are stationary or moving. Teaching the operation of a piece of test equipment is an example of a stationary skill, while a flight simulator which responds to the operator's movements is an example of a moving operational skill. Error fidelity is important in simulations of motor skill performance. The M1 troubleshooting and maintenance

tasks are procedural skills. Procedural-maintenance tasks do not require as high performance error fidelity as perceptual-motor maintenance skills or operations skills.

3. Task frequency: Tasks which are critical, but which are unlikely to be frequently encountered in the field require may require greater performance error fidelity. Non-critical tasks may require less error fidelity.

4. Performance level: Tasks which must be mastered or overlearned to the level of automaticity may require greater performance error fidelity.

The troubleshooting and maintenance skills in MTP-RC involve psychmotor skills, but the goal of MTP-RC training was teaching the soldiers the procedural skills required to perform these tasks. The design team decided to use the lowest level of performance error fidelity for both Troubleshooting Simulations and Maintenance Simulations. The decision to use the lowest level of performance error fidelity means that the soldier does not see the consequences of an incorrect response: the soldier is given immediate corrective feedback in order to prevent diverging any further from the correct path. The design team's decision to use this level of performance error fidelity was based on their consideration of the institution's requirements, the nature of the content and limited resources. The amount of training time the Reserve Component Units can make available to soldiers is quite limited, therefore the institution wanted the soldiers to complete as much training as possible in the available amount of time. Allowing a higher level of performance error fidelity would have allowed a soldier to diverge from the correct path and travel down that path for a while before learning that he had made an error. Allowing this long diversion would not have been an effective instructional strategy considering how limited the time the soldier has to complete his training. Creating the extensive computer program code to allow higher performance error fidelity would have been very expensive. In addition, allowing the soldier to diverge from the correct procedural path would distract him or interfere with his learning the intended content.

Level of Guidance

Level of guidance is concerned with the amount of guidance in the form of textual prompts and visual cues that should be included in a lesson. The prompts and cues may be provided by printed materials used with the CBT lesson or by online information. If M1 technical manuals (TMs) are used to perform the task simulations, the TMs are, in effect, part of the lesson material.

The level of prompting and cuing provided to soldiers as they troubleshoot depends upon the extent of their previous training and experience with the system needing repair. The assumption is that the amount of guidance provided should vary inversely with the soldier's knowledge and experience of the system. As a soldier's understanding of the system increases, he requires less guidance to troubleshoot previously unencountered problems. For example, a soldier who has little job experience or system knowledge will require substantial guidance to successfully troubleshoot previously unencountered problems. This guidance can be supplied in the form of detailed, illustrated step-by-step instructions, mnemonic devices, or automatic prompts.

The highest level of guidance for a troubleshooting or maintenance skill would include all of the following:

1. General knowledge: general information about the type of system and about the specific system requiring troubleshooting (e.g., general information about the function of the pistons within a cylinder block).

2. Procedures: specific procedures to be followed to perform the job task (e.g., the steps to remove the cylinder head).

3. Specifications: specifications of the system (e.g. the wear tolerance of the piston rings in millimeters).

The design team considered the factors of audience, institution, and content before deciding which level of guidance to provide. The soldiers who will receive MTP-RC training have little or no previous experience with the M1 tank and will need substantial guidance. The institution does not expect the soldiers to have experience with the systems and requires that the soldiers use detailed support materials to guide their performance of the procedural tasks. A key goal of MTP-RC training is to train soldiers to use their Technical Manuals as they perform troubleshooting and maintenance procedures. The content available to the instructional designers provided all the information required for the soldier to perform the job tasks.

For these reasons, the design team decided to provide the soldier with the highest level of guidance throughout all simulations. At this level of guidance the soldier is guided through each procedural step in a troubleshooting or maintenance task by written instructions and illustrations. The guidance is provided by the procedural TMs and by online help available for every step. The courseware provides general information about the system. The Technical Manuals provide the lists of procedures to follow, and the specifications of the systems.

Template Components

At this stage in MacroDesign the following steps had been completed: (a) the design team had used decision-making guidelines to aid content selection decisions, (b) task analysis and training task analysis led to the identification of generic enabling objectives, (c) template design began with a review of of decision-making guidelines that aided the selection of instructional strategies for teaching the generic enabling behaviors. With these stages completed, the design team continued the template design by identifying instructional components and content elements, by identifying elemental interactions, and by writing pseudocode. Each of these steps will be described next.

Instructional Components and Content Elements

MacroDesign includes all the steps used in the SAT model of lesson design, and includes two additional steps. The first additional step involves the identification of instructional components and the content elements of which they are composed. Instructional components are the sections that make up lessons. For example, in MTP-RC courseware most cognitive lessons are composed of five instructional components: Introduction, Overview, Instruction, Practice, and Review (Figure 5). Each of these instructional components is itself composed of content elements. Content elements are the constituent parts of instructional components. For example, the instructional component Introduction of a lesson is composed of the following content elements: a brief description of lesson topic, a statement of the objective, a description of the importance of the lesson and any unusual features it might contain, and a description of the relationship of this lesson to other lessons.

INSTRUCTIONAL COMPONENTS OF A TYPICAL COGNITIVE LESSON

1. Introduction
2. Overview
3. Instruction
4. Practice
5. Review

CONTENT ELEMENTS OF INSTRUCTIONAL COMPONENT "Introduction"

1. Description of lesson topic.
2. Statement of objectives.
3. Description of lesson.
4. Description of relationship of this lesson to others.

Figure 5. Instructional components and content elements.

At this point in the design process, no actual content was generated, but rather, only the types of content elements were identified. Although these content elements may be included in a storyboarded lesson, they would not necessarily be identified prior to the development of the storyboards themselves and would not be articulated in this form. This step provided the design team with information that would be used during the creation of elemental interactions, the creation of pseudocode, and the specification of data sets. These terms will be defined below.

Elemental Interactions

MacroDesign used a technique from Courseware Engineering, that of separating content design from logic design. The Courseware Engineering technique of modularity allows content and program logic to be separated. The separation of content and program logic facilitates design efficiency by aiding in the identification of those elements of content or program functions which are similar enough to be coded as a subroutine. The process of identifying subroutines is preceded by the specification of elemental interactions.

The specification of elemental interactions is the second additional step performed by the design team in MacroDesign. Elemental interactions are two part narrative descriptions that detail how the learner interfaces with a content element, and describe how the content element is functionally connected to other parts of the program. Elemental interactions describe the learner's behavior and what the system will do in response to that behavior, e.g. the learner marks the touchscreen and the system analyzes the mark.

As a result of analyzing the instructional components and content elements, the design team was able to identify which elemental interactions would be used repeatedly throughout instruction. Elemental interactions which describe a consistent and repeated user interface are recurring elemental interactions. For example, in MTP-RC Troubleshooting Simulations, whenever the soldier marks the "Help" icon on the screen, the system always responds the same way by presenting two levels of Help: Step Help and Screen Help. In Step Help, the soldier is told what page in the Technical Manual to be on, what step to perform next, and what to mark on the screen. Figure 6 illustrates a model of Step Help which is a recurring elemental interaction.

STEP HELP

Turn to page ________ in Technical Manual _______.

Do step ______ now.

Mark _______ on the screen.

Figure 6. Example of a recurring elemental interaction.

Although the information presented in the blank spaces varies with the specific screen display, no matter where in the simulation the soldier is, the Help interface and the system response are consistent.

The identification of recurring elemental interactions is a key feature of MacroDesign and is the result of Courseware Engineering. Because a recurring elemental interaction can be used with different instructional components and content elements, recurring elemental interactions represent interactions that can be coded efficiently as a subroutine by the computer programmer. A programmer needs to write only one block of code to perform the required interaction and this subroutine can be used repeatedly in different instructional components and content elements. Compared to the storyboard method of describing content and program code, the description of elemental interactions leads to more efficient coding.

The blank spaces in Figure 6 represent data items. Data items are the specific information that must be inserted within a template to make it complete. The collection of all the data items required for one lesson is the data set. Data sets are the specifications of the specific content that have to be supplied by the instructional designers in order for the interaction to occur. The instructional designer must specify which page of which Technical Manual the soldier should be referring, which step to perform, and what to mark on the screen. These are data items to fill the blanks in the example in Figure 6.

In addition to aiding the identification of subroutines and establishing a consistent user interface, these MacroDesign techniques allow for a more efficient use of the time of the senior instructional designer and senior courseware developer (programmer). In MacroDesign, the senior instructional designer designs and describes the elemental interactions and the senior courseware developer creates the program code that allows the interaction to occur. But, these interactions can not be implemented until the data items have been written and coded. The job of creating the specific data items is performed by junior instructional designers. The job of coding the data items is performed by junior courseware developers. This division of labor and specialization is cost-efficient because it limits the demands on the scarce time of the senior designer and courseware developer to the high-level design processes. The task of implementing these designs is carried out at lower cost by the junior designers and courseware developers, thus freeing the senior staff for designing additional templates or working on other projects.

Pseudocode

The identification of instructional components, their component content elements, elemental interactions, and the data set provided the design team with an easy to understand prose description of exactly what would occur when the lesson was used. These narrative descriptions of the elemental interactions were used by the team when they designed pseudocode for the instructional components.

At this stage in MacroDesign, the narrative descriptions of elemental interactions were translated into pseudocode descriptions that contained the same information but in another language. Pseudocode is a short description of the structure and logic flow of a computer program. In form, it is halfway between a narrative description and a computer language. Pseudocode is a communications tool that permits high level descriptions of computer programming logic. The use of pseudocode facilitated efficient communication among designers and programmers during the design and production of MTP-RC courseware.

The pseudocode that the design team generated had to be complete enough that the senior courseware developer could use it as a basis for code development. ADAPT, the authoring language of the MicroTICCIT CBT system, was the language the senior courseware developer used to write the program code. The pseudocode also had to be simple enough that other members of the design team could understand how the lesson worked and how the content elements within an instructional component were functionally related. For example, the narrative description of a recurring elemental interaction read, "Students will be required to mark the name of the part that is being described." Translated into pseudocode it read, "DO GETINPUT". GETINPUT was the name of a programming subroutine that was used repeatedly to accept the learner's mark on a touchscreen monitor. GETINPUT is a pseudocode description of a recurring elemental interaction that the senior courseware developer converted into a subroutine using ADAPT.

The product that the design team produced in this stage of design was made up of two parts reflecting Courseware Engineering's separation of content and program logic, a narrative description of the elemental interactions, and a translation of these in the form of pseudocode. Figure 7 contains a small sample of both the narrative description of elemental interactions and a piece of the related pseudocode. The sample is taken from a practice component of the Name, Locate, Function template developed for MTP-RC. The data items are identified by a naming convention in which the words in data item names are separated with periods.

Narrative Description

Identify part name based on function description. Locate part on system graphic. Description of interaction; A part's functional description and a list of part names will be displayed on the screen. Students will be required to mark the name of the part that is being described. If a correct response is given, an unlabeled system (or subsystem) graphic will be displayed. Students will be required to mark the location of the named part on the graphic. If an incorrect response is given.....

Pseudocode for Template

```
FIRST
          SHOW BRIEF.DESCRIPTIVE.TEXT
          GIVE PART.NAME CHOICES

NEXT
          DO   GETINPUT------------------------------->(16)*
          DO FEEDBACK -------------------------------->(18)*
          IF RESPONSE WAS NOT THE CORRECT ANSWER,
          TRY AGAIN
......
```

Note: * indicates recurring elemental interactions and the template page on which the pseudocode for that elemental interaction can be found.

Figure 7. Example of narrative description and pseudocode.

Courseware Engineering techniques are reflected in different areas of MTP-RC courseware production. First, standard code for recurring elemental interactions is used repeatedly throughout the program. This led to improvements in design efficiency by emphasizing the use of existing program components (recurring elemental interactions), treating them like subroutines. Second, there is the use of high level pseudocode to describe the flow of the program's logic. In MTP-RC, the use of Courseware Engineering provided a clear picture of how a lesson would function. The use of elemental interactions clearly communicated the nature of the program's user interface and the structure of the program's content -- each important features of a CBT storyboard. Specifying the logic of instructional components in pseudocode provided a clear high-level description of the lesson/program organization and structure, and overcame the limitations imposed by traditional storyboarding techniques. In addition, the two components communicated the overall structure of the program and the ways in which elemental interactions, content elements, and instructional components related to one another -- information typically lacking in most storyboards. Thus, the separation of content description from program logic led to improved communications among designers and courseware developers, which was one of the goals the design team hoped would result from the use of Courseware Engineering.

Once the design team wrote a template it was reviewed by instructional designers and the senior courseware developer (Figure 2, Steps 5 and 6). A senior courseware developer conducted a resource review of the elemental interactions described in the template. In this resource review, the courseware developer assessed the feasibility of writing the code to perform the interactions described. The courseware developer considered whether the design team's plans were within the limitations of the CBT system being used, assessing the types of branching required and the amount of information that might be required per screen display. The courseware developer also estimated the amount of time and other resources that would be required to code the template.

In this review, the courseware developer sometimes suggested alternate coding approaches that could be taken to make the process more efficient or to take advantage of an authoring language's strengths and avoid its weaknesses. The design team modified the template to incorporate the courseware developer's recommendations. While the senior courseware developer was reviewing the template from the coding perspective, instructional designers reviewed the template with an eye towards suggesting improvements in the generic instructional strategies described in the template. Thus, each major component of the template was subjected to review and to revision.

Prototype Development

When a template received approval from the senior courseware developer and instructional designer, work began on creating the actual code for the template (Figure 2, Step 7) as part of the process of creating a lesson prototype. At the same time, instructional designers began to write the content or data items required by the data sets for instructional components of a prototype lesson. Task analysis and training task analysis had earlier led to the identification of the general types of content for a template, for example the Name, Locate, Function template. At this point, the instructional designers selected the specific data items which would be taught within the lesson prototype. For example, the instructional designers identified the specific parts of a particular system or component that would be taught.

Once design work reached this point of generating content at the lesson level, instructional designers conducted a two phase review of instructional strategies using the decision-making guidelines (Figure 2, Steps 8a and 8b). This review was similar to the two phase process used earlier to guide selection of instructional strategies for the design of the template, however this time the goal of the review was to use the guidelines to make decisions for the specific lesson. At the lesson level, decisions had to be made regarding visual fidelity as an instructional strategy. This was the only strategy that had to be considered at the lesson level because the others were decided at a course or template level.

Visual Fidelity is the degree to which graphic and/or video images used in instruction mirror reality. Reiser and Gagne (1983) have discussed media selection strategies, but their approach is designed for selecting the appropriate media for delivering an entire body of instruction. The purpose of the MTP-RC guidelines is to assist instructional designers in selecting the appropriate visual fidelity of specific images for specific lessons.

The visual fidelity of images ranges from the realistic to the abstract. Photographically produced video images are extremely realistic, while cartoons can illustrate real objects but in a stylized fashion. Between these two extremes lies a variety of forms with varying degrees of visual fidelity. In general, visuals are particularly useful for conveying the spatial relationship of parts.

The instructional designers used the decision-making guidelines to select levels of visual fidelity throughout MTP-RC lessons. Instructional designers specified enhanced video image to show the soldier a tank part in context and used unenhanced video to show the soldier a detail of a part, such as in overviews of tank systems. Realistic graphics were specified when a video image would not have provided the required clarity or simplicity, or when it was impossible to obtain a video image of the part. For example, the tank compartment is so small that it was impossible for a cameraperson to photograph a good view of the tank commander's station. Consequently, a detailed drawing was used. Cartoons were specified by instructional designers both for presenting complex information in a simplified form and in order to increase interest and inject humor into the lesson. The review of visual fidelity decision-making guidelines helped the instructional designers' selection of graphics content for the data items required by the lesson.

In addition to specifying the visuals for a lesson, instructional designers wrote display text, generated practice items and specified all the data items required by a lesson. Once the courseware developers had completed coding the template, the courseware developers entered the data generated by the instructional designers into the code template on-line. The resulting product was a prototype lesson (Figure 2, Step 9). This prototype lesson was was debugged and revised (Figure 2, Step 10). Only after a template had been designed and the prototype lesson tested did full scale lesson production begin (Figure 2, Step 11). When the revisions were completed, work began on the design of the next template.

CONCLUSION

When the design team began work on MTP-RC, they were faced with the challenge of efficiently and rapidly producing approximately 200 hours of courseware. Before courseware development began, the design team assessed the design tools available to them. They concluded that existing design models did not contain all the design tools required to efficiently produce complex non-linear instruction, because these design models were originally crafted to meet the requirements of linear instruction. Specifically, the design team believed that existing design models tend to focus on lesson level design which leads to unnecessary duplication of effort when many lessons must be designed. The design team also found that instructional designers' content selection decisions and instructional strategies decisions should be informed by guidelines. Finally, the design team found that the storyboard method of communicating content and program logic descriptions is awkward and inefficient. Having identified the shortcomings of existing design models, the design team added tools to the standard SAT model and named this enhanced process MacroDesign.

In MacroDesign, design tools and techniques are applied at the course level rather than the lesson level. In the order in which they were employed, the enhancements included:

1. Decision-making guidelines to aid the design team's selection of content.

2. Task analysis and training task analysis focused to identify similar skills and behaviors within the selected body of content.

3. Decision-making guidelines to aid the selection of appropriate instructional strategies during template design.

4. Courseware Engineering techniques to separate content descriptions from computer program logic.

Because it was not feasible to develop all the possible content into courseware, the design team sought ways to select which content to develop for MTP-RC. The design team established and reviewed decision-making guidelines which highlighted the effect that four environmental factors have on content selection. Specifically, the design team considered the needs of the sponsoring institutions and those of the training audience. They considered the criticality and field utility of the content and finally the design team considered which content could be developed given the resources and the need to produce state-of-the-art CBT.

The design team determined that to meet the production schedule, they needed to utilize an approach which would avoid the needless duplication of steps required when producing a large number of lessons using standard design models. Consequently, during task analysis and training task analysis, the design team focused their attention on identifying similar skills and behaviors within the body of content. Enabling skills were grouped by behavioral domains and then analyzed to identify similarities among them. Then, the need for instructional segments was defined and the design team generated generic enabling objectives and identified the skills and knowledge required to support the performance of these objectives. This process led to the design of templates.

A template is a detailed description of both the instructional strategies that will be used, and the description of the interactions which will occur within the parts that make up a lesson. The design team selected appropriate instructional strategies using decision-making guidelines. At the course and template level, the decision-making guidelines assisted the design team in selecting the appropriate strategies to use with regard to feedback, passing level, learner control, visual fidelity, simulation fidelity, performance error fidelity, and level of guidance. Each set of guidelines included information that described how environmental factors affect the selection of instructional strategies. Template design also included the identification of generic instructional components, content elements that make up a component, and data sets to fill the elements. This step led to the identification of recurring elemental interactions which courseware developers could code as subroutines.

The template is first written in pseudocode, a language which is a blend of narrative description and a programming language. Pseudocode descriptions are an application of Courseware Engineering and have at least three benefits.

1. It separates the design of content and screen displays from the design of program logic, thus providing a clear description of the hierarchical structure and organization of the lesson.

2. The technique leads to efficient coding because recurring elemental interactions are coded as subroutines.

3. It allows instructional designers to communicate lesson design, including both content and logic, to other designers, subject matter experts, and courseware developers.

In conclusion, the enhancements the design team made to the standard SAT model proved to be effective. As the use of computers for training increases, instructional designers increasingly will be called on to produce CBT. Their ability to efficiently produce CBT depends on their willingness to use the design tools available to them. The design efficiency of CBT also will be aided by designers' ability to increase the number and sophistication of non-linear design tools. The adaptation and integration of innovative courseware design techniques is one way to speed this process.

REFERENCES

Allessi, S. M., & Trollip, S. R. (1985) Computer-based instruction: Methods and Development. Englewood Cliffs, NJ: Prentice-Hall.

Andrews, D. H. & Goodson, L. A. (1980). A comparative analysis of models of instructional design. Journal of Instructional Development, 3(4), 2-16.

Dick, W. & Carey, L., (1985) The systematic design of instruction (2nd ed.) Glenview, IL: Scott, Foresman.

Eschenbrenner, J. A., Devries, P. B., Miller, J. T., & Ruck, H. W. (1979). Methods for collecting and analyzing task analysis data (Contract No. F33615-77-C-0076). Brooks Air Force Base, TX: Air Force Human Resources Laboratory.

Gagne, R. M., & Briggs, L. J. (1979). Principles of instructional design (2nd ed.). New York: Holt, Rinehart and Winston.

Joseph, J. H., & Dwyer, F. (1984). The effects of prior knowledge, presentation mode, and visual realism on student achievement. Journal of Experimental Education, 52, 110-121.

Reiser, R. A., & Gagne, R. M. (1983). Selecting media for instruction. Englewood Cliffs, NJ: Educational Technology Publications.

Stacy, E. W. Jr. (1985). Impact on courseware engineering on design and production code. Paper presented at the Society of Applied Learning Technology Conference on Simulation and Training Technology for Increased Military Systems Effectiveness, Arlington, VA.

Wulfeck, W. H., Ellis, J. A., Richards, R. E., Wood, N. D., & Merrill, D. M. (1978). The instructional quality inventory: Introduction and inventory (NPRDC SR 79-3) San Diego, CA: Navy Personnel Research Center.

APPENDIX

DECISION-MAKING GUIDELINES TO AID SELECTION OF INSTRUCTIONAL STRATEGIES

This appendix contains the decision-making guidelines the MTP-RC design team developed and used to guide their selection of instructional strategies used in the design of templates and of individual lessons.

In the following pages, each instructional strategy is defined, discussed in general terms, and the affect of four environmental factors on the selection of instructional strategies is discussed. These decision-making guidelines supplement the general procedures instructional designers normally follow when selecting instructional strategies. They are not intended to be used as if they represent scientific quantities; they are introduced into the design process to assure that these instructional issues will be addressed deliberately and carefully by the design team at the appropriate time in the design process.

Designers using these guidelines must have information about the requirements of the sponsoring institution, the intended audience for whom the instruction is being developed, the content selected for instruction, and the resources available for program development. With access to this information, the designer should read through the guidelines and identify which instructional strategy is most appropriate given the institution, the audience, the content, and the resources. Because the environmental factors are not weighted, situations may arise factors may conflict with one another. For example, the institutional requirement may conflict with the resource requirement. Under such circumstances, the design team should attempt to resolve the conflict by establishing the priorities of the environmental factors with the sponsoring institution. Once the instructional designer has selected the appropriate strategy to use, the next phase of the design process can continue.

In the discussion of resources in each guideline, reference has been made to both "development time" and "delivery time." Development time refers to the amount of time required to create the program, lesson, or segment, including designing templates, writing content, writing program code, creating graphics, etc. This definition includes both the number of hours of labor involved, and the total span of time from planning to implementation. For example, instruction that requires video production usually involves long development times because of the pre-production planning required. Delivery time is the estimated amount of time it will take for an average soldier to complete the program, lesson, or segment.

The guidelines discussed in this appendix are:

1. Passing level
2. Learner control
3. Feedback
4. Guidance
5. Performance error fidelity
6. Visual fidelity
7. Simulation fidelity

These guidelines are defined in the following discussions.

PASSING LEVELS

Definition

The performance level required for passing a lesson.

General Discussion

Passing level is the acceptable performance level. It is the measure of the soldier's mastery of the content with respect to an explicit instructional objective. Performance is measured by comparing the soldier's execution of the task with the criterion for success. Criterion standards exist along a continuum from one hundred percent to less than sixty percent. Figure A-1 lists three passing levels on a continuum.

HIGH <--- LOW

3.1 COMPLETE MASTERY

3.2 PARTIAL MASTERY

3.3 NO MASTERY

Figure A-1. Passing level.

Passing Levels

3.1 Complete Mastery

Institution. The institution requires soldiers to perform the training task without error and the institution is committed to longer training times.

Audience. Complete mastery is appropriate for soldiers who, after training, must perform the actual task without any errors. This passing level may be appropriate with an audience who typically makes errors on the job due to inattention or carelessness. It should be considered if audience is inattentive to instruction or training. Complete mastery may be required of soldiers who are being tested on tasks that are extremely critical and which are prerequisite to other critical skills. As the relationship increases between the current skill and subsequent dependent skills, the higher the mastery level should be set (Dick & Carey, 1985).

Content. This level of passing is appropriate for content that must be well learned to prevent a serious threat to either the soldier or equipment. This level is appropriate when errors lead to life threatening situations, or when extensive damage may result from errors. It is also appropriate when the content should be overlearned or automatized by the soldier, or when a high level of transfer from training to actual performance is required.

Resources. Creating the feedback and remedial instruction for complete mastery requires the most development time and therefore greatest cost. This level of performance requires the most delivery time. Strictly enforcing high criterion standards for items that are irrelevant or insignificant to the course objectives significantly increases the time and cost required to meet the criterion for passing (Torshen, 1977).

3.2 Partial Mastery

Institution. The institution requires that the great majority of soldiers perform at a high level, but complete mastery is not a requirement. To achieve this level of performance, the institution has established passing levels below 100 percent.

Audience. Partial mastery is appropriate when the audience typically performs well in the job setting and whose lives are not threatened should they perform the task at less than complete mastery.

Content. Partial mastery is an acceptable passing level when the content places a substantial focus on practicing the instructed task. It also is appropriate when components of the content are incidental or transitional actions, and are not of critical importance.

Resources. If critical actions are a subset of the range of actions required in a given task, then a subject matter expert must be available to make judgments about the criticality of the task and the level of performance required.

Creating the feedback and remedial instruction for this passing level requires more development time and therefore greater cost. Because extensive practice is frequently a strategy used to assure high passing levels, more time may be required to deliver the instruction than when lower passing levels are acceptable. However, less delivery time is probably required than is needed for level 3.1.

3.3 No Mastery

Institution. The only objective of the institution is to expose the soldiers to the content without regard to their level of performance.

Audience. Soldiers who are in need of orientation, or initial exposure to the content.

Content. This passing level is appropriate when the sole purpose of the content is contextual in nature or when the purpose of the content is to act as an advance organizer or to provide motivation.

Resources. Less development time and cost is incurred when extensive feedback and corrective instruction are not used. Careful consideration should be given to the decision whether to develop instruction at this level as it may divert resources from more crucial tasks.

LEARNER CONTROL

Definition

Learner control refers to the degree to which the learner can control the selection of content and the sequence in which instructional elements are studied.

General Discussion

Designers must make decisions about learner control for all levels of a course. In MTP-RC the levels were units, lessons, segments and components of segments. At the unit level, the choice was which system to study. At the lesson level, the choice was Principles of Operations (PoPs) or Troubleshooting. At the segment level within a PoPs lesson the choice was Name, Location, Function segment or Input, Process, Output segment. Within a segment the choice was Introduction, Overview, Instruction, Practice or Review.

Learner control has a broad range. On one end, the soldier makes all the decisions about what content to study and the sequence to learn it in. On the other end, the instructional designer makes these decisions, and in the case of CAI these decisions are implemented by the computer program. In between the extremes of total learner control and total program control is the intermediate ground in which the soldier may control the content but not the sequence, or may control the sequence but not the content. The continuum of learner control is illustrated in Figure A-2.

LEARNER CONTROL ------------------> ------------> PROGRAM CONTROL

2.1 Learner controls both content and sequence

2.2 Learner controls content
Program controls sequence

2.3 Program controls content
Learner controls sequence

2.4 Program controls content
and sequence

Figure A-2. Learner control.

Learners who are provided with advisement are more able to responsibly and effectively manage their own learning strategies. (Johansen & Tennyson, 1983) Advisement may be offered in the form of progress notices related to their achievement of the overall goal, or the program may offer meaningful advice or suggest strategies to users based on their performance. Allowing soldiers to exercise choice both increases their satisfaction with the learning experience and promotes transfer of learning (Glaser, 1984).

Levels of Learner Control

2.1 Content and Sequence

The student has complete control over his instructional environment. He may select both the instructional elements to be studied and the order in which they are studied.

Institution. The institution accepts the fact that this level of control will allow that soldiers to skip instructional elements, thereby missing information that the institution may regard as important.

Audience. Employing this level of control should be limited to soldiers who are capable of evaluating their own instructional needs and progress towards mastery.

Content. This level of control is most appropriate for content that contains instructional elements that are neither hierarchically nor sequentially related. The content should not depend on the acquisition and understanding of one skill in order to acquire and understand another skill. It may also be appropriate for content whose elements are sequentially related but for which the order of study does not greatly influence mastery.

Resources. In this mode, the designer cannot assume that soldiers have already studied elements in the program. Each element must be complete within itself, without assuming mastery of previous content. Creating content suitable for this level of learner control therefore requires increased development time. This level of control has the potential for the least delivery time of any level of control.

2.2 Content Control

The soldier may decide which elements of instruction to study, but the sequence of instruction within that selection is prescribed by the computer program. For example, the soldier may select a unit on a topic, but sequence of lessons within that unit is controlled by the program. This was the learner control option chosen for MTP-RC so that soldiers could choose to study any tank system (covered by a course unit). The sequence of instruction within that unit was preset by the designers; soldiers had to study the Principles of Operations lesson before the Troubleshooting lesson.

Institution. The institution is willing to provide freedom of choice related to high level content choices by soldiers.

Audience. This level requires soldiers who are capable of evaluating their own instructional needs at a relatively high level by selecting the general content areas to be studied.

Content. This level is appropriate when high level elements of the content are neither hierarchically nor sequentially related, but lower level elements are. For example, a soldier would be able to study Lesson II after Lesson I, but once they began the lesson, the sequence of the instruction within the selected lesson would be program controlled. This level of control is also appropriate when the order of instruction at any level has a significant impact on mastery.

Resources. This level allows for assumptions about previously studied elements within a high level content division. Development time is less than required for level 2.1, but still higher than when more program control is exercised by the designer.

2.3 Sequence Control

The program controls which instructional elements the soldier will study, but within those elements, the soldier may choose the sequence of study.

Institution. The institution makes relatively high level decisions related to broad categories of content, but leaves the lower level sequencing decisions to the students. The institution is willing to allow students to control the order in which they study the lower level content even though this may result in increased training time, for example, because the material was not presented in the most effective sequence. The institution is willing to accept a possible increase in time because this result is compensated by the soldier's greater satisfaction derived from controlling the lesson sequence.

Audience. This level of control requires soldiers who are capable of evaluating their own instructional needs at a relatively low level. They do not decide which content categories to study, but they may control the order in which they study the elements within the prescribed content.

Content. This level of control is appropriate when high level elements are related either hierarchically or sequentially, but when lower elements are not. For example, the program controls the path of the soldier from Lesson I to Lesson II and the soldiers decide if they wish to complete exercise C before exercise A, within the lesson.

Resources. This level of control allows for assumptions related to previously studied high level elements. Elements within a single content area must be independent of one another. In other words, if a term or concept is new to the lesson, the designer cannot assume that the soldier has already learned it in an earlier element of the lesson. Consequently, whenever the term is used in a lesson element it will require explanation. The development time required by this level is similar to that of 2.2 above.

2.4 Program Control

The computer program decides both the instructional elements to be studied and the order in which they will be presented to the soldier.

Institution. The institution wishes to exert complete control over both the content and the sequence of the instructional program.

Audience. Use of this level of control is appropriate for soldiers who can not effectively manage their own path through the lessons.

Content. This level of control is appropriate for content whose component parts, at all lesson levels, are hierarchically and/or sequentially related.

Resources. This level allows for assumptions related to previously studied instructional elements at all levels. It requires the least development time of all four levels of control. However, it will normally require the most delivery time.

FEEDBACK

Definition

Feedback is the procedure used to tell a student if his response to an instructional event, usually a practice item or test question, is right or wrong. Feedback might be in the form of speech, gesture, text or graphics.

General Discussion

Feedback can be used to:

1. Reinforce a correct response.

2. Correct an incorrect response.

3. Provide additional information related to specific incorrect responses.

The amount of feedback that can be given to the student can vary from simply telling him if an answer is right or wrong to providing additional explanations and instruction. Simple feedback might consist of a short statement such as, " Incorrect. Try again." Comprehensive feedback explains why a response was incorrect, what the correct answer is and why it is correct. In addition, such feedback may include a restatement of key points contained in the lesson. For example, " Smooth Washer is incorrect. A smooth washer will not hold the axle in place. You should use a LOCKING WASHER. A locking washer prevents the axle from coming loose. Remember, whenever you have a rotating shaft or axle, secure the end with a Locking Washer."

Figure A-3 lists feedback completeness along a continuum from no feedback to comprehensive feedback. Feedback is mainly influenced by content and resource factors. Unlike the other six criteria presented in this appendix, the criterion Feedback is minimally influenced by the environmental factors of audience and institution. Therefore, the discussion of the various feedback levels is restricted to outlining how these two factors influence the appropriate level of feedback.

DEGREE OF COMPLETENESS

LOW ---> HIGH

1.1 NONE
1.2 LIMITED
1.3 PARTIAL
1.4 COMPLETE
1.5 COMPREHENSIVE

Figure A-3. Feedback continuum.

Feedback Levels

1.1 No Feedback

No feedback is given following a soldier's response.

Content. No feedback is an appropriate feedback level when any response might provide the soldier with clues that might assist him to answer another related question. Typically, such content is a test or quiz. Content in these forms does not usually provide feedback after each response. Instead, when the soldier has completed the test, he is informed about his overall performance.

Resources. Because no feedback is generated, no instructional design time and no coding time are needed. No expenses are incurred.

1.2 Limited Feedback

Feedback informs soldier whether his response is either right or wrong.

Content. Limited feedback is appropriate for content whose purpose is to introduce the soldier to the content area or for reviewing content that they already know very well. This level is appropriate for content that requires the soldier to provide limited verbal information, e.g., the soldier states a fact or names an object. Under these circumstances, the verbal performance of the soldier may not need to be very precise. Therefore, the feedback need not be very complete. When the soldier must name a few parts, then feedback may be limited to either "right" or "wrong."

Resources. Only a limited amount of instructional design time is required for generating these simple feedback messages. The coding of this kind of feedback is usually quite easy.

1.3 Partial Feedback

Feedback informs the soldier whether or not his response is correct, gives the right answer, and explains why it is right.

Content. Partial feedback is appropriate for content that requires the soldier to perform simple procedures in which there are only a few possible variations. It is also useful when the content places emphasis on the correctness of the response. When the range of wrong answers is so great that it difficult to predict all incorrect responses, then partial feedback would be appropriate.

Resources. Instructional designers need to generate the content required to explain why a particular response is the correct response. This may require more consultation with the subject matter experts Coding this level of feedback requires more time than those described above.

1.4 Complete Feedback

If soldier chooses the incorrect response, the feedback informs him that his answer is wrong, explains why it is wrong, gives the right answer, and explains why it is right.

Content. Complete feedback is appropriate when the content requires the soldier to name a long list of parts. In this situation, it may be necessary for the feedback to identify the parts of the list that the soldier omitted. This level of feedback is also appropriate for content that teaches motor skills or procedures. The extent of the feedback will depend on the number of steps required to perform the task. Removing the dip stick to check the oil level would receive Partial feedback. A more complex task such as changing the oil filter might require complete feedback that identifies where in the procedure the soldier went wrong and explains what the correct procedure is.

Resources. More time is needed for instructional designers to generate instructional material that explains why incorrect responses are wrong and why another response is correct. This may require designers to spend more time consulting with SMEs. Coding feedback responses at this level is more time consuming and more costly than those discussed above.

1.5 Comprehensive Feedback

If the soldier's response is incorrect, the feedback informs him that his answer is wrong, explains why it is wrong, gives the right answer, explains why it is right, and provides additional instruction.

Content. Comprehensive feedback is appropriate when the content emphasizes intellectual skills such as making distinctions, applying rules, solving a problem not experienced before by the soldier. Reiser and Gagne (1983) have stated that the feedback provided in response to an intellectual skill requires precise corrective feedback. For example, content that requires a soldier to read a map to decide the best location for artillery is complex and the feedback provided should be designed to overcome the soldier's misinterpretations of the content. In this case, where the soldier applies the wrong rule, the feedback should explain what the correct answer is, why it is the correct answer, and provide supplemental information useful to the soldier.

Resources. Producing comprehensive feedback requires greater resources than any of the other levels of feedback. Feedback costs increase in direct relation to the complexity of the feedback messages. Creating more complete feedback messages requires more writing and more coding. Therefore, it costs more to create comprehensive feedback than limited feedback. When the instructional designer must create a special message for each incorrect response of a multiple-choice question, considerable writing is required. Likewise, the coding necessary to check each individual item is also increased. All of the choices must be reviewed by the SME and this requires more time and personnel. In summary, as feedback messages become more complex, more resources are required.

LEVEL OF GUIDANCE IN TROUBLESHOOTING AND MAINTENANCE INSTRUCTION

Definition

Level of guidance is concerned with the amount of guidance in the form of textual prompts and visual cues that should be included in instruction that requires the performance of a troubleshooting or maintenance task. Troubleshooting and maintenance instruction always provide some guidance. However, guidance typically would not be provided when the soldier's skills are tested. The prompts and cues may be provided on the screen or with printed materials used with the computer-based training lesson. If technical manuals (TMs) are used to perform the task simulation, the TM's are, in effect, part of the lesson material. Guidance differs from feedback in that guidance is given before a soldiers response, whereas feedback is given after a response.

General Discussion

The level of prompting and cuing provided to soldiers as they troubleshoot depends upon their skill level with the system needing repair. The assumption being made is that as soldiers' understanding of the system increases, they will require less guidance as they troubleshoot previously unencountered problems. Soldiers who have little job experience or system knowledge will require substantial guidance to successfully troubleshoot previously unencountered problems. This guidance can be supplied in the form of detailed, step-by-step instructions or text prompts that are abundantly illustrated with visual prompts. On the other hand, soldiers who have had substantial knowledge and experience with a system probably will require less guidance, thus fewer prompts.

The highest level of guidance for a troubleshooting or maintenance skill would include all of the following:

1. General knowledge: general information about the type of system and about the specific system requiring troubleshooting (e.g., general information about the function of the pistons within a cylinder block).

2. Procedures: specific procedures to be followed to perform the job task (e.g., the steps to remove the cylinder head).

3. Specifications: specifications of the system (e.g. the wear tolerance of the piston rings in millimeters).

Figure A-4 shows the relationship between the level of guidance that should be incorporated within CBT lessons with the soldier's amount of system knowledge and experience. The table shows that as a soldier's knowledge and experience of the system increases, the need to provide guiding prompts decreases.

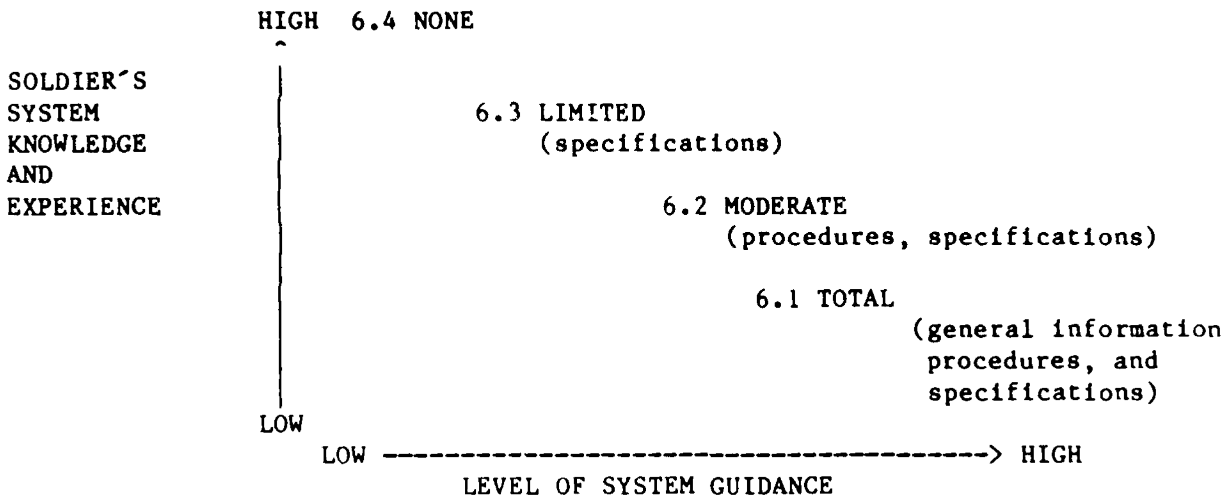

Figure A-4. Levels of guidance.

Levels of Guidance

6.1 Total Guidance

In total guidance, soldiers who have neither experience with nor knowledge of the system are guided through troubleshooting by following detailed step-by-step written instructions (technical manuals) that are profusely illustrated, such as SPAs manuals. Additional guidance may be given as on-line prompts and cues. This is the level of guidance incorporated in MTP-RC courseware. It was an institutional requirement that the tasks be performed with the detailed guidance of the SPAs manuals. In addition, on-line prompts were used in guided demonstrations to help locate parts because the M1 equipment was new to most of the intended audience. General system knowledge was embedded into the troubleshooting procedures to increase the soldiers' understanding of the tank and the complex relationships between components.

Institution. The institution does not expect the soldiers to have experience or system knowledge in order to perform the job task. The institution provides the soldiers with guidance in the form of well designed support materials. The institution expects the soldiers to perform the job task by following the detailed support materials that are provided.

Audience. The soldiers have had little or no previous experience with the system. The soldiers know how to use the technical manuals and will have access to them when they perform the actual task. This level of guidance is appropriate when the soldier will have little opportunity to practice working with the actual equipment during training.

Content. Instructional materials assume no prior system knowledge on the part of the soldier. The source documents (technical manuals, job aids) provide all information required to perform the job tasks. This includes providing: (a) general knowledge about the system or similar systems, (b) an ordered listing of the sequence of activities required to perform the job task, and (c) particular data related to the system, such as specifications. The descriptions of the performance activities must be divided into discrete unambiguous steps. When necessary, detailed graphics must be included as cues.

Resources. This level of guidance requires instructional designers to conduct thorough task analyses that must be checked with the SMEs. It requires the development of of all three types of information; system knowledge, procedures, and specifications. Because this level of guidance requires the development of all three types of information, it is usually the most labor intensive to develop. However, the amount of resources depends greatly upon the quality of the job aids and technical manuals. Instruction derived from accurate and well written job aids and TMs requires less SME and ID time than instruction derived from job aids of inferior quality.

6.2 Moderate Guidance

In the moderate guidance mode, soldiers still require guidance to perform job tasks by following written instructions, but they have some understanding of the system or similar systems and therefore require less guidance than in total guidance. The soldiers' prior system knowledge provides them with an overall troubleshooting plan while the soldiers depend on technical manuals for specific details of each step and for specifications.

Institution. The institution requires that job tasks be performed by persons who have limited experience and knowledge of the system and who continue to require guidance in the form of support materials. The institution expects soldiers to perform the job task with prior system knowledge, but to rely on the support materials provided for system specific procedures and specifications.

Audience. The soldiers have had some experience, training, and understanding of the system. The soldiers are able to use the support materials as a checklist while following the procedures.

Content. The content was created under the assumption that the soldiers have more experience with the system and/or more training on the system than soldiers who require guidance. The source materials provide clear and complete explanations of how to perform the task and include graphic illustrations when necessary. However, the source materials provide fewer prompts than those used with total guidance. Unlike the source materials in total guidance, these materials do not provide information about tasks with which it is assumed the soldier is already familiar. Instead, the source material provides only the procedural steps to be followed and system specifications for new tasks. For example, the task of removing a wheel axle (a new task) requires performing the subprocedure of first removing the wheels. Only the limited guidance provided by a prompt to remove the wheels would be provided. The soldier would not be prompted to remove the lug nuts; it is assumed the soldiers already know how to do this. The emphasis here is on guidance through new tasks, with less guidance for more familiar or earlier tasks.

Resources. This level of guidance usually requires fewer resources to develop than total guidance because it does not require the need to provide general information about the system. However, the amount of resources does depend on the quality of the job aids and TMs.

6.3 Limited Guidance

In limited guidance soldiers perform the job task using reference materials that provide only limited guidance. The soldiers consult the support materials for specific information (i.e. torque specifications for tightening bolts) but also depend upon their own knowledge and experience to perform tasks. This level of guidance provides the fewer prompts than the other two levels, yet it remains instructional.

Institution. The institution is willing to allow soldiers to rely more on their understanding of the system and be less dependent upon the guidance contained within the support materials. The institution may need to provide more subject matter expert time to help generate content.

Audience. Soldiers should have troubleshooting and maintenance experience, but not necessarily with the system being studied. They should also understand how to use the technical manuals for reference.

Content. The source materials were created under the assumption that the soldiers have general knowledge of the system and experience performing the job tasks. The only information provided to the soldiers are data about the system, such as the specifications.

Resources. This level of guidance usually requires the least resources compared to the other two levels. This is because instruction does not contain reference to procedural step and general system knowledge. Only specifications are provided.

6.4 No Guidance

Student actions are totally derived from their knowledge of the system if no guidance is given. Students must be able so solve all problems without any guidance from support materials such as job aids or technical manuals. This mode may be appropriate for tests or practice of tasks. If feedback is given, a simulation with no guidance can still be instructional. Refresher training is a good application of the no guidance mode with feedback.

Institution.The institution must be confident that the the soldiers' experience and skill level will enable them to perform the task without guidance from support materials or on screen guidance. The institution must have defined the tasks to allow performance without technical manuals. This mode could not be used in MTP-RC because all MTP-RC tasks required use of the TMs.

Audience. Simulations with no guidance can be used for an audience that may already possess the target skills. In this case, the simulation would provide refresher training or practice.

Content. The tasks being trained with no guidance must be ones that require no guidance either on screen or from printed materials. This mode can be used as a pretest to screen out soldiers who have mastered the task. This mode was not suitable for MTP-RC because all of the trained tasks required constant reference to the technical manuals, even for skilled repairmen.

Resources. Instructions with no guidance will require the least amount of resources to develop because the additional materials do not have to be developed or integrated with the courseware.

PERFORMANCE ERROR FIDELITY

Definition

Performance Error Fidelity refers to the degree to which the consequences of incorrect actions will be shown to the soldier during the performance of a troubleshooting or maintenance simulation. Performance Error Fidelity is a special case of feedback used within simulations.

General Discussion

When designing simulations, the instructional designer must decide what to do when an incorrect response is given. In some cases, it is desirable to flag the response immediately after it is given. The result is that soldiers will never see the consequences of the incorrect response. In other cases, the incorrect responses can be ignored until they lead to a natural conclusion. Following is a discussion that provides guidelines related to levels of performance error fidelity and the conditions under which they might be used.

When selecting a level of Performance Error Fidelity, the following issues should be considered.

1. The criticality of the error and how it affects the chances of achieving success.

2. Type of skill being taught. There are two basic types of skill that are typically simulated - operational skills, and troubleshooting/maintenance skills. Operational skills are further categorized depending upon whether they are stationary or moving. Teaching the operation of a piece of test equipment is an example of a stationary skill, while a flight simulator that responds to the soldier's movements is an example of a moving operational skill.

   Error fidelity is important in simulations of motor skill performance. Troubleshooting or maintenance tasks involve learning procedural skills. Procedural-maintenance tasks generally do not require as high performance error fidelity as perceptual-motor maintenance skills or operations skills. Non-critical tasks that the soldier will perform frequently in the field require less error fidelity.

3. Task frequency: Tasks that are critical, but that are unlikely to be frequently encountered in the field require more practice and may also require greater performance error fidelity. Non-critical tasks that the soldier will perform frequently in the field may require less error fidelity.

4. Performance level: Tasks that must be mastered or overlearned to the level of automaticity may require greater performance error fidelity.

It is important to note that flagging the error and providing feedback or knowledge of results, by definition lowers the fidelity of the simulation. Refer to Figure A-5.

LOW--------------------------------------> HIGH

7.3 TOTAL

7.2 PARTIAL

7.1 NONE

Figure A-5. Performance error fidelity.

Levels of Performance Error Fidelity

7.1 None

Soldiers are prohibited from seeing the consequences of an incorrect response and immediate corrective feedback is presented to prevent the soldiers from diverging any further from the correct path.

Institution. The institution can permit the soldiers only a small amount of time for training and wants the soldiers to complete as much training as possible in that time.

Audience. Other than those audience factors described above, the audience does not have a significant effect on the level of Performance Error Fidelity.

Content. This level of performance error fidelity is appropriate when showing the consequences of the error would distract or interfere with learning the content. It is also suitable for content in which errors are unlikely, or when errors are non-critical and would usually be corrected by the soldier during the actual task performance.

Resources. This mode requires the least delivery time of those considered. This mode saves time by preventing the soldier from pursuing the wrong learning path. It also requires the least development time.

7.2 Partial Error Fidelity

Allow a soldier to see the consequences of incorrect responses until damage to equipment or safety of personnel would result from the errors. At that point the soldier receives a warning of impending damage and he is allowed to extricate himself from the problem.

Institution. The institution wants instruction to be as realistic as possible, short of allowing complete freedom. The institution wants soldiers to experience incorrect paths that might be encountered on the job.

Audience. Same as for no performance error fidelity.

Content. This mode is suitable for content in which soldiers may make critical errors or errors that the soldier must resolve before they become critical. It can be used for content that requires the soldier to recognize warning signs of impending danger and take the correct actions to prevent it.

Resources. This mode requires more development and delivery time than no fidelity, but less than total fidelity. As the level of performance error fidelity increases, the complexity of the branching necessary increases exponentially. This increase in possible branching scenarios requires considerably more time for designers to write and for programmers to code the required materials.

7.3 Total Error Fidelity

Allow the soldier to make incorrect responses until the selected course of action comes to its natural conclusion within the simulation.

Institution. The institution does not have the resources to test the soldiers with the actual equipment, because it is either unavailable or too dangerous for this purpose.

Audience. Total performance error fidelity is well suited to train experts who are undergoing final testing, or soldiers who must be thoroughly familiar with all system contingencies.

Content. It is suitable for: (a) dynamic operational skills, (b) tasks that are encountered infrequently but have potentially serious consequences, (c) material that requires the modeling of the serious consequences and that must be performed without errors, and (d) tasks that require rapid response times.

Resources. This is the most expensive level of error fidelity to develop as it requires the most writing and programming. This mode may also require the most delivery time. Developing Performance Error Fidelity at this high level may require large electronic storage devices in order to store and retrieve the large number of branching possibilities.

VISUAL FIDELITY

Definition

The degree to which graphic and/or video images used in instruction reflect reality.

General Discussion

Reiser and Gagne (1983) discussed media selection strategies, however, their approach is designed for selecting the appropriate media for delivering an entire body of instruction. The purpose of this criterion is to guide instructional designers in the selection of the appropriate visual fidelity of specific images within lessons. Visual Fidelity ranges from photographically produced (video) images which are extremely realistic to more abstract images that illustrate real objects in a stylized fashion. Cartoon drawings are an example of this stylized form. Between these two extremes lie forms with varying degrees of visual fidelity. Figure A-6 shows six levels of visual fidelity.

HIGH VISUAL FIDELITY ---------------------------> LOW VISUAL FIDELITY

4.1 UNENHANCED VIDEO

4.2 ENHANCED VIDEO

4.3 REALISTIC COMPUTER GENERATED GRAPHICS

4.4 ENHANCED COMPUTER GENERATED GRAPHICS

4.5 COMPUTER GENERATED LINE DRAWINGS

4.6 COMPUTER GENERATED CARTOONS

Figure A-6. Visual fidelity.

There is evidence to suggest that the effectiveness of visuals depends upon the soldier's previous knowledge of the subject being taught. Although students with a relatively low general knowledge benefit equally well from all types of visuals, students with moderate to high levels of knowledge about the subject seem to benefit more from visuals with higher levels of fidelity. (Joseph & Dwyer, 1984) In general, visuals are particularly useful for conveying the spatial relationship of parts.

Levels of Visual Fidelity

4.1 Unenhanced Video

Conventional video images without graphic enhancement. Video can be used to emphasize distinctive visual features of a real object or task performance as it aids the soldier to recognize distinguishing stimuli. Video can increase the soldier's retention of textual information (Levie & Lentz, 1982).

Institution. The institution is willing to pay the cost of producing unenhanced video images because the actual equipment will not be available during training or because not enough equipment is available for all soldiers.

Audience. Unenhanced video is appropriate when the audience will have limited opportunities to see and or work with the actual equipment. Unenhanced video is useful when the soldiers, without aid, must recognize and cope with extraneous stimuli. Soldiers must learn to focus their attention on appropriate cues.

Content. Unenhanced video is appropriate to show the physical appearance of a piece of equipment in or out of context. If in context, the parts must be immediately distinguishable from the surrounding parts. It is also suitable for content that emphasizes reality or content that is motivational in nature. Unenhanced video is also appropriate for demonstrating the performance of procedures, particularly those that need to emphasize the motions involved.

Resources. Typically, this level of visual fidelity is the second most expensive option to produce. Unenhanced video usually requires location shooting and some post-production processing. The cost of revising this kind of image is expensive.

4.2 Enhanced Video

Video images that have been graphically enhanced for emphasis. Enhancement may include, arrows, pointers, labels, masks on irrelevant details, or highlighting to emphasize relevant details.

Institution. The institution cannot provide the actual equipment for training or it is not available in sufficient numbers to train all the soldiers. The institution has the resources that permit production of enhanced video.

Audience. The audience's entry-level knowledge of the content is an important factor in determining whether enhanced video is appropriate. It is appropriate when the audience has had or will have limited opportunities to see and or work with the actual equipment. This mode may be especially useful in assisting soldiers with identification skills.

Content. Enhanced video can be used when the intent of the content is to show, in context, the physical appearance of an isolated part of a larger piece of equipment. This level of fidelity is useful for content that points out "critical attributes" or content that shows what the object looks like and its relative position to its surrounding. Content that places emphasis on a soldier's ability to recognize a part or distinguish it from its surrounding may need the use of highlighting or arrows, therefore enhanced video would be an appropriate choice.

Resources. This is the most expensive image option. It usually includes all the costs associated with unenhanced video plus the added costs required to create the graphics used to focus the soldier's attention. Like unenhanced video, enhanced video images are expensive to revise.

4.3 Realistic Computer Generated Graphics

Graphic images that portray real objects in a realistic way, that is, with color and proportion maintained.

Institution. Several factors can lead to use of this option. In some cases, the institution cannot provide the actual hardware, or the hardware is too dangerous or easily damaged to allow use for training. At other times, arrangements cannot be made for video production, or a shot is too difficult to make.

Audience. Most appropriate when soldiers have had some prior contact with the equipment being studied. If the soldier has had no previous experience with the actual object, exposure to the real object is desirable. However, if this is not possible, a realistic computer-generated image would be acceptable.

Content. The content explains the purpose, function, or use of a part or pieces of equipment. Realistic computer generated images are useful for content that requires showing small parts in great detail as well as content that requires frequent revisions of the visual images. Realistic computer-generated images are appropriate when it is necessary to emphasize the steps of a task procedure (i.e., a troubleshooting/maintenance procedure) and when higher visual fidelity is not an overriding factor.

Resources. This option is useful when logistics make it difficult to obtain real equipment either during delivery, training development, or when acquisition of acceptable still or motion images is difficult. The image can be revised at a lower cost than video images can.

4.4 Enhanced Computer-Generated Graphics

Computer-generated images that have been enhanced with arrows, pointers, labels, colors, masks to obscure irrelevant details, or highlighting to emphasize important details.

Institution. The institution cannot provide the actual hardware, or the hardware is too dangerous or easily damaged to allow use for training, or when arrangements cannot be made for production, or a shot is too difficult to make. The institution finds the cost of producing enhanced video images too expensive, or the institution anticipates the images will require periodic revisions.

Audience. This level of visual fidelity is appropriate for soldiers who are already familiar with the location of a particular part but who need to understand the function of the part. It is appropriate to train identification skills to soldiers who have had or will have only limited exposure to the actual equipment.

Content. This level of visual fidelity is useful for conveying content that emphasizes identification skills. Such content may require detailed images of objects with areas masked out to eliminate distracting stimuli. It also is appropriate for content that requires the highlighting of a details through the use of attention getting colors, arrows, or labels. This level of fidelity is useful for content that relates part to whole. As with enhanced video images, enhanced computer-generated graphics are appropriate when it is necessary to emphasize the steps of a task procedure (i.e., a troubleshooting/maintenance procedure) and when higher visual fidelity is not an overriding factor.

Resources. This mode costs slightly more to produce and revise than Realistic Computer Generated Graphics.

4.5 Computer Generated Line Drawings/Diagrams

Graphic images that portray real objects without providing complete detail and which are intended to show characteristics such as shape, relationship among parts, etc. These diagrams show conceptual relationships. They illustrate organizational structure and are useful for directing attention. Diagrams are useful in illustrating concepts and relationships between concepts in a content area, especially how concepts are classified.

Institution. The institution cannot provide the actual hardware, or the hardware is too dangerous or easily damaged to allow use for training, or when arrangements cannot be made for production, or a shot is too difficult to make. The institution finds the cost of producing video images too expensive, or the institution anticipates the images will require periodic revisions.

Audience. Computer generated line drawings are effective when soldiers have low verbal skills and when they require simplification of complex relationships.

Content. Computer generated line drawings are useful when the content requires showing the physical or conceptual relationship among parts. It is also effective for content that teaches

1. Intellectual skills (Reiser & Gagne, 1983),

2. A sequence of events,

3. Discrimination or Generalization.

Line drawings also may be useful when video images are not appropriate or unavailable because of the physical location or size of the actual object.

Resources. Compared with the other visual forms discussed, this visual form requires the least developmental resources. It is the least expensive to produce and images can usually be inexpensively revised.

4.6 Computer Generated Cartoons

Graphic images that are caricatures of real or imaginary persons or objects.

Institution. The institution accepts their use to improve motivation and increase soldier satisfaction.

Audience. Cartoons may be used to supplement textual presentations when the audience has poor reading skills. Cartoons may be inappropriate for use with higher ranking individuals and when they are used they should not appear to insult or demean audience members.

Content. Cartoons facilitate the simplification of information and are useful in presenting content that is conceptually complex or for presenting mechanical information to a non-technical audience. Content that is intended to motivate, or that is dry and lacking stimulation can be be made more interesting through the use of humorous cartoons. Content that needs to depict real life events but that cannot be captured on video can be presented through the use of cartoons. When cartoons are used care should be taken that they do not distract from the content.

Resources. Cartoons can be expensive to produce as they require both a cartoonist and some graphics production. With the development of more sophisticated graphics software editors, the costs are becoming less significant.

SIMULATION FIDELITY

Definition

Simulation fidelity refers to the degree of similarity between the stimuli provided and actions taken during training and the stimuli and actions taken during the actual performance of a task.

General Discussion

There are three main characteristics which describe simulation fidelity. Simulation fidelity is concerned with how much the simulation duplicates the:

1. Appearance and feel of the real object or process.

2. Motion or visual cues of the object or process.

3. Environment in which the tasks actually takes place.

The degree of simulation fidelity can determine the effectiveness of the training. Simulation fidelity also can affect how well the skills learned in the simulation will be transferred to an actual task in real field conditions. Simulation fidelity is closely interrelated with two other criteria: Performance Error Fidelity, and Level of Guidance in Troubleshooting and Maintenance Instruction. Simulation Fidelity involves the degree of similarity between the training task and performance of the actual task. Level of Guidance is more specifically focused upon the amount of guidance that should be included in lessons requiring practice of a troubleshooting or maintenance task. Performance Error Fidelity refers to the degree to which the consequences of incorrect actions will be shown to the soldier during the performance of a troubleshooting or maintenance simulation. Each of these criteria is discussed separately.

Figure A-7 locates two levels of simulation fidelity; "complete", and "program-based." Complete simulations are extremely realistic and include all actions required to perform a job task in the job environment. Program-based simulations do not consist of all steps; some steps have been eliminated to emphasize the more critical skills.

DEGREE OF SIMILARITY BETWEEN SIMULATION AND REAL TASK

HIGH	INTERMEDIATE	LOW
5.1 COMPLETE		
	5.2 PROGRAM-BASED	

Figure A-7. Simulation fidelity.

Levels of Simulation Fidelity

5.1 Complete

Complete simulations include all the actions required to perform the task in the job environment. Highly realistic visuals or graphics are presented.

Institution. Complete simulation is appropriate when real equipment is unavailable during training or available in such limited numbers that it will serve little instructional purpose. It also is appropriate when error free task performance is an institutional requirement.

Audience. High fidelity simulations are appropriate for soldiers who already have attained a high degree of skill, especially in operational skills (Baum, Smith, & Hirshfeld, 1982). Students returning for refresher training benefit more from highly developed operational simulations than soldiers who are just beginning their training. Inexperienced soldiers who must learn critical tasks may begin with lower fidelity simulations and, when they are more experienced, complete their training with simulations of higher fidelity.

Content. High fidelity simulations are most appropriate for operations skills such as visual motor coordination. Troubleshooting, or fault diagnosis skills (procedural skills) do not require high degrees of fidelity (Johnson, 1981). High fidelity simulations are appropriate for activities that must be well practiced and free of errors because of the serious consequences of the errors.

Resources. Costs increase dramatically as fidelity is increased. Complex simulations require extensive amounts of time to design and develop. Programming is usually quite complex. Delivery times may be time consuming since all procedures must be simulated.

5.2 Program-Based

Program-based simulations are those in which steps or groups of steps have been eliminated from the simulation of the task so that the remaining steps can be emphasized during a particular stage of training. Program-based simulations have a lower degree of fidelity than complete simulations. They are less realistic than complete simulations in that they do not attempt to simulate each task being performed. However, the steps that are simulated may be quite realistic.

Institution. Program-based simulation is appropriate when real equipment is unavailable during training or available in such limited numbers that it will serve little instructional purpose. The institution can provide only limited training time and requires that training emphasis be given to critical tasks in order to maximize cost-effectiveness of training. Program-based simulations were used for maintenance and troubleshooting procedures in the MTP-RC courseware to avoid spending the soldier's time on simple mechanics' tasks such as torquing bolts.

Audience. Program-based simulations may be appropriate for soldiers who already have mastered some of the skills required to perform the main task, or soldiers who lack those skills and who do not now have the time to learn them. When soldiers will not acquire all skills required to complete a task, program-based simulation is appropriate. For example, a troubleshooting procedure may require a decision regarding a part that only a supervisor is qualified to make. A program-based simulation would allow soldiers to complete all steps prior to that decision, provide the decision, then allow soldiers to continue the simulation. This type of simulation also is useful when a complete simulation would be inappropriate because of the amount of time it would take to complete.

Content. This form of simulation is better suited for troubleshooting/maintenance skills than for operational skills, which are best simulated with higher fidelity. Program-based simulations assume that training can be effective in some situations, such as teaching maintenance skills, even when some steps are skipped. Program-based simulations may be employed when the content is complex, time consuming, and/or needlessly repetitive. Learning such content can be made more effective by skipping the less important steps while simulating the critical skills. Program-based simulations may be used when the content permits steps or groups of steps to be skipped without diminishing the effectiveness of instruction.

This mode also may be effective when the content requires prerequisite skills that the soldiers do not possess yet, or when they do possess them but it is ineffective and time consuming to require the soldier to practice them. For example, it would be appropriate in a lesson designed to teach the set of procedures to remove the main axle assembly from a motor vehicle. Performing this procedure might consist of six subtasks. Instead of simulating all the steps, a program-based simulation might include, only a selected subset. The first and second steps of this task are to lubricate then remove twenty-four lug nuts that secure each wheel. Rather than simulating these steps, a program-based simulation would inform the soldier that these steps had already been performed. The soldier would then be required to simulate steps three through six; removing the wheel, removing the CV joints, attaching a sling to the axle, hoisting the axle.

Resources. The program-based mode is suitable when constraints on the amount of available training time requires that critical skills be trained while less important ones are skipped. Compared with complete simulation, this mode reduces the amount of training time. Careful task analysis is needed to identify the key tasks and to determine which prerequisite skills the soldiers do or do not possess, or which steps can be skipped without negative effects. More time is required for this analysis than for complete simulation, however, program coding is usually somewhat less extensive.

APPENDIX REFERENCES

Baum, D., Smith, D., & Hirshfeld, S. (1982). Specification of training simulator fidelity: A research plan (Tech. Rep. No. 558). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Dick, W., Carey, L. (1985). The systematic design of instruction (2nd ed.). Glenview, IL: Scott, Foresman.

Glaser, R. (1984). Education and thinking: the role of knowledge. American Psychologist, 39(2), 93-104.

Johansen, K. J. & Tennyson, R. D. (1983). Effect of adaptive advisement on perception in learner-controlled, computer-based instruction using a rule learning task. Educational Communications and Technology Journal, 31, 226-236.

Johnson, S. L. (1981). Effect of training device on retention and transfer of a procedural task. Human Factors, 23, 257-272.

Joseph, J. H., & Dwyer, F. (1984). The effects of prior knowledge, presentation mode, and visual realism on student achievement. Journal of Experimental Education, 52, 110-121.

Levie, W. H., & Lentz, R. (1982). Effects of text illustration: A review of research. Educational Communications and Technology Journal, 30, 195-232.

Reiser, R. A., & Gagne, R. M. (1983). Selecting media for instruction. Englewood Cliffs, NJ: Educational Technology Publications.

Torshen, K. M. (1977). The mastery approach to competency-based education. New York: Academic Press.

Weitz, J., and Adler, S. (1973). The optimal use of simulation. Journal of Applied Psychology, 58, 219-224.

Yuan-liang, D. S. (1984). A review of the literature on training simulators: Transfer of training and simulator fidelity (Report No. 84-1). Atlanta: Georgia Institute of Technology, Center for Man-Machine Systems Research.