Research Report 1223

LEVEL II

TRAINING DEVELOPERS DECISION AID FOR OPTIMIZING PERFORMANCE-BASED TRAINING IN MACHINE ASCENDANT MOS

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U. S. Army

Research Institute for the Behavioral and Social Sciences

August 1979

U. S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the Deputy Chief of Staff for Personnel

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

Field	Content
1. REPORT NUMBER	Research Report 1223
2. GOVT ACCESSION NO.	
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle)	TRAINING DEVELOPERS DECISION AID FOR OPTIMIZING PERFORMANCE-BASED TRAINING IN MACHINE ASCENDANT MOS
5. TYPE OF REPORT & PERIOD COVERED	Final Report July 19, 1976-July 19, 1977
6. PERFORMING ORG. REPORT NUMBER	--
7. AUTHOR(s)	William J. Pieper, Neil R. Guard, William T. Michael [redacted] Raymond S. Kord[redacted]k
8. CONTRACT OR GRANT NUMBER(s)	DAHC-19-76-C-0043
9. PERFORMING ORGANIZATION NAME AND ADDRESS	Applied Science Associates, Inc. Box 158 Valencia, PA 16059
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	2Q763731A770
11. CONTROLLING OFFICE NAME AND ADDRESS	Commandant U.S. Army Air Defense School ATTN: ATSA-TD-CD
12. REPORT DATE	Aug [redacted] 79
13. NUMBER OF PAGES	57
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue, Alexandria, VA 22333
15. SECURITY CLASS. (of this report)	Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	--

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

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18. SUPPLEMENTARY NOTES

Monitored technically by M. H. Strub and J. M. Lockhart, ARI Field Unit, Fort Bliss, Texas.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

- Training developer decision aid
- Training development specialist
- Task training prescription
- Response acceptance mechanism
- Resident option cost indicator
- On-the-job option cost indicator
- Training option cost indicator

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

An analytical process was developed for generating Training Specifications to assist Training Development Specialists (TDS) in deciding what, where, and how tasks within a Military Occupational Specialty (MOS) are trained. The model was developed in two major segments: (1) a theoretical or idealized model, and (2) a procedural model based on the concepts developed in the first segment. The manual model process simply has the TDS work through partition logic charts to generate the Training Specifications. The computer-aided model

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(6) (10) (15) (16) (12) 69 (11) (18) ARI (19) RR-1223 (9) Final rept. 19 Jul 76-19 Jul 77

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

i

Unclassified 032170

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Item 20 (Continued)

requires the TDS to complete a task data sheet for each of the MOS tasks. The TDS is then required to run the programs associated with the model. The outputs produced by the programs are the same as the output arrived at by following the partition flowcharts. The three outputs generated by the model are Training Prescriptions, Training Hierarchies and Sequences, and Training Costs.

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Office, Deputy Chief of Staff for Personnel
Department of the Army

August 1979

Army Project Number
2Q763731A770

Individual Training in
Air Defense

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FOREWORD

A major concern of the Army Research Institute for the Behavioral and Social Sciences (ARI) is performance-oriented individual skill development and evaluation. The ARI Field Unit at Fort Bliss, Texas, in its work unit area, "Models for Deciding Priorities, Methods, and Locations for Training Air Defense Tasks," is concerned with development and validation of models which offer contingency planning for air defense training program developers through manipulation of task variables, personnel variables, methods, media, institutional variables, unit-readiness variables, and cost variables.

This report describes the development of an analytical process model for generating training specifications to assist Training Development Specialists (TDS) in deciding what, where, and how tasks within a Military Occupational Specialty (MOS) are trained. The effort reported here was completed in the first year of a three-year research project by Applied Science Associates, Inc., under Contract DAHC19-76-C-0043 with ARI. Work to be completed during the second and third years of the project includes (1) implementation and evaluation of the model in manual and computer modes with instructional handbooks for each mode, (2) continuations of computer mode model tryouts and sensitivity analyses, (3) analysis of Army schools computer systems, and (4) development and evaluation of stand alone self-paced training materials for the model.

The research was done under Army Project 2Q763731A770, responsive to the needs of the U.S. Army Air Defense School at Fort Bliss.

JOSEPH ZEIDNER
Technical Director

BRIEF

Requirement:

To develop a process model for generating training specifications to assist Training Development Specialists (TDS) in deciding what, where, and how to train tasks within a Military Occupational Speciality (MOS).

Procedure:

The development of the process model was performed in two major segments - an idealized model and a procedural model. The procedural model was based on the concepts developed in the idealized model. These concepts included the (1) identification of the user population; (2) analysis of TDS experiences and background; (3) determination of the types of decisions made by the TDS and of the outputs resulting from these decisions; and (4) review of the current state of military training design technology.

Model development was divided into three partitions. The first partition deals with processes/decisions considering a single task with task training prescriptions as output. Task training prescriptions for each task consists of the following elements: (1) training algorithm, (2) stimulus media, (3) response acceptance mechanism, (4) training method, and (5) training setting.

The second partition deals with processes/decisions considering the tasks collectively with task assignments to initial residential training, on-job-training, and no training as output. The components of this partition consist of building task hierarchies and establishing task priorities for initial training.

The third partition deals with the development of a set of relative costing procedures which are used to determine the acceptability of various training options.

The model was developed to be responsive to criteria changes as a function of policy and fiscal situations and requires prompting by the TDS during the process of developing training.

Findings:

Model users were identified as the personnel responsible for development of plans of instruction, training materials, criterion tests, and on-job-training plans. Model outputs include (1) task training prescriptions, (2) Training Options, and (3) cost summaries.

Training prescriptions consist of (1) a training algorithm; (2) a stimulus for training the stimulus element of the task; (3) a response acceptance mechanism for accepting, evaluating, and providing feedback for the task response set; (4) a training method supporting the stimulus medium and response acceptance mechanism; (5) verification of the method for the training algorithm· and (6) a training setting.

Training options for initial residential training, on-job-training, or no training are based on task hierarchies and task training priorities. Cost summaries include verification of adequate individual real time for equipment and non-equipment on-job-training options and cost ratios for selected training options.

Utilization of Findings:

The Training Developer Decision Aid may be used for contingency planning through the manipulation of task variables, methods, media, institutional variables, unit readiness variables, and cost variables and examination of the effects of these variables in combination on training prescriptions, training options, and relative cost. The model also provides a record of the decisions made and permits an analysis of the impact of the decisions throughout the process.

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SECTION I

INTRODUCTION

Background and Problem Definition

As the approach to training in the military services has become more sophisticated, the problems facing the training manager in assigning persons to various training programs have also become much more complicated. Not many years ago, every soldier followed a more or less specific path from enlistment through training. Typically, following basic training, the individual was sent to a resident school in his specialty. He then went to the field where he received some on-the-job training (OJT). After that, he might go back for advanced schooling. Although there were some variations depending upon the individual's particular specialty, the training manager did not have many decisions to make other than how to handle the number of troops required to fill the quotas. People were funnelled through available courses at available locations, using available instructors, equipment, and facilities.

Recently, this approach has come under scrutiny for a variety of reasons. First, the trend is toward training being more directly related to performance on-the-job. Some of the training includes a greater amount of actual job-like practice, whereas other training is more performance-oriented than formerly, although it may not include actual practice. A second reason is the greatly escalated personnel costs in the military. With pay increases and personal services cost increases, it is highly desirable to get individuals into operational units as soon as possible, rather than keeping them in training for extensive periods. There is a desire to shorten training by increasing its efficiency. There is also an indication that, for certain kinds of tasks and for certain kinds of training, OJT in the unit is more efficient and cost-effective than resident training.

The use of the old single-training program is also being reviewed because of the increasingly sophisticated ways of developing and presenting training. In the typical training approach, a skilled instructor, who may have been through an instructor school, provided lectures, sometimes followed up by laboratory exercises, but always in a classroom-like situation. In recent years, a wider variety of instructional approaches has become available. These have included various kinds of programmed instruction, as well as greater use of audio-visual materials, increased use of training devices, and some use of part-task trainers. OJT has also received additional emphasis, since a person engaged in OJT in an operational unit can contribute to the readiness of that unit while he is not specifically involved in training.

The increased use of task analysis coupled with additional emphasis on performance-related training, criterion-reference testing, and skill qualification tests further complicates the training problem. Previously, training developers specified the subject matter to be presented to the trainees. Now, a list of performance objectives is specified instead of the subject matter. Usually, it is not possible for all performance objectives of a job to be dealt with adequately in training, so a training development specialist (TDS) must somehow rank order these and make certain that the trainees achieve the most important objectives. The TDS is therefore faced with an N-dimensional decision process. Interactions among the many variables in this decision process are complex enough to make it unrealistic to expect a TDS to make comprehensive decisions about training programs without some assistance in structuring all of the relevant information. Thus, there is a need for a training development decision model which can assist the TDS in making training-related decisions.

The term model, as used above, denotes a logically consistent representation of training and training-related situations which captures the essential variables and processes of that situation, and which permits answers to specific questions about training to be analytically derived. To be used by the TDS, the model should consist of a set of procedures for processing information from various sources in order to produce training specifications that will assist the TDS in his decision making. The model must include ways to reflect the real world situation, while at the same time providing useful outputs. In order to be useful, model outputs must also be accurate and must be achieved efficiently. The overall goal for the present study is to develop a training developers decision model to aid in the process of deciding what to train, where to train, and how to train soldiers to perform their duties.

The problem for model development is multifaceted. First, where possible, the model has to be developed to provide the TDS with quantitative information and criteria that indicate the direction his decisions should go on any of the major dimensions for each training task. On the other hand, the model should not be falsely accurate; it should not include a large number of pseudo-sensitive computations based on very crude input information. Additionally, the model should indicate situations where it can not provide a firm direction for a decision, while identifying the factors that the TDS should take into account in making the required decision. The model has to be able to utilize qualitative information as well as quantitative information. It should not be strictly a computational model; it should allow decisions to be influenced by factors which are not quantifiable. Lastly, the model has to be as comprehensive as possible, but not so cumbersome that the training development specialist can not use it.

An additional requirement is that the aid not be so voluminous as to prevent its own use. A prime example of this situation is the Instructional Systems Development (ISD) process outlined in TRADOC Pamphlet 350-30. Although the concepts and procedures of the ISD process are logical, the five volumes of TRADOC Pamphlet 350-30 present a considerable obstacle to effective implementation. Therefore, any model developed for use by current training decision makers should incorporate the sophistication of the ISD and other relevant processes in a simplified form that will enhance their usability.

Overview

The development of the Training Developers Decision Aid (TDDA) was performed in two major segments. The first was the development of a conceptual model. The second involved the development of a procedural model. Development of the conceptual model was carried through the process stage. The procedural model began with these concepts and continued through development of actual user procedures. In some instances, factors identified in the conceptual model were not implementable due to the lack of required data.

The first step in the development of the model was to determine who the model's users would be, and what types of training decisions they make. Individuals currently involved in training development activities were contacted in order to identify those individuals whose job matched the description of a training development specialist. This step was necessary since the Army does not have a position entitled "Training Development Specialist." It was possible to identify individuals in the training development field whose job was to determine what to train, how to train, and where to train. Once the TDS positions, and the individuals in these positions were identified, discussions were held to determine what kinds of decisions they make and what outputs result from these decisions. During the resulting discussions, it became apparent that the criteria to be satisfied by the model are not constant, but dynamic. Training criteria change as a function of current training policy and fiscal constraints. Therefore, it was necessary to develop a model which would permit extensive training developer interactions in its operation. In addition, the backgrounds of the various training developers were not identical in terms of their familiarity with ISD procedure. Thus, the model also had to be developed in a way that would guide the training developers during the training development process.

As part of the first step, the outputs generated by the TDSs were specified to ensure that the TDDA output would be similar in content and format to information currently in use. This was done primarily to identify model output requirements, and to enhance the understandability of the model for the training decision makers. Such standardizations would maximize the probability that the aid would be used by individuals involved in developing training specifications.

Finally, the current status of military training design technology was reviewed to insure that the conceptual model reflected the present state-of-the-art in training development. Various procedures for specifying and evaluating training algorithms, methods, media, equipment, facilities, instructor/supervisor requirements, and costs were reviewed. The primary documents were TRADOC Pamphlet 350-30, Training Analysis and Evaluating Group Reports 16 and 21, and RAND's Modia report.*

The results of the interviews, output analyses, and literature review were used to specify model outputs and the gross model flow. The TDDA was partitioned so that the decision processes would be concerned with only one level of information at a time. This had the effect of simplifying procedures for d termining the extent to which the process under development included all necessary steps and considered all required data. The "partitioning" also helped to insure that processes at each level were complete before moving to the next step.

Development of the model partitions was performed with two objectives in mind: First, all questions of what, how, and where to train must be considered. Second, the sequence of model operations with respect to individual tasks versus collective tasks is considered. The resulting model partitions were as follows:

1. Processes and decisions for considering a single task.
2. Processes and decisions for considering collective tasks.
3. Cost evaluation.

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* See references section for a listing of these documents.

In the first partition, a detailed definition of the model outputs and processes required to specify training requirements for a single task in terms of the training algorithm, media, method, content, and setting were developed. At each step, the definition consisted of specifying the outputs and processes in terms of variables, ranges of values, output formats, and process flow. Model development for the second partition dealt with procedures for considering collective tasks. The second partition accepts as input individual task training specifications and combines them into a single course.

The cost analysis portion (Partition three) was placed last in the development process. This was done in order to facilitate the identification of points where various cost trade-offs would be most beneficially applied. Placing cost considerations last also led to the development of only those cost elements that were absolutely necessary for the operation of the model.

During preliminary development of the decision aid one assumption was made: This assumption was that an adequate task listing would be available for input to the model. No assumptions concerning the adequacy of the task listing were made.

SECTION II

MODEL DEVELOPMENT

Model Specifications

Developing the TDDA's output specifications was a multi-faceted problem. Several uses and users of the product were considered and consulted. The uses given primary consideration were the following:

1. Development of course Plans of Instruction (POI)
2. Development of Training Materials
3. Development of Criterion Tests
4. Development of OJT plans

At present, the Army does not have a single individual in each Military Occupational Specialty (MOS) who performs or monitors all of the above functions. That is, the Army does not have a single "Training Developer" for each of its MOSs. Therefore, in order to define and develop the training specification it was necessary to contact a representative from the agencies engaged in developing resident courses, preparing materials for resident and on-the-job courses, developing performance tests, and developing individual and unit training plans.

Since it would not have been possible to contact the personnel for all MOSs at even one school location (e.g., Ft. Bliss, TX) it was decided to limit initial development work to two MOSs. The two MOSs chosen for initial development of the decision model were 16E (HAWK Fire Control Crewman) and 16R (ADA Short Range Gunnery Crewman). The primary criteria for selection of these MOSs were, first, that the personnel were working on a current Army weapons system; second, that the tasks in the MOS were dictated primarily by the system equipment and equipment operation; and third, that the MOSs were ones in which the school would agree to support the current effort. Having made the MOS selection, personnel in the concerned Directorates of Training Development (DTD) were contacted to discuss the items to be included in the training specifications. The specific DTD offices contacted were:

1. Individual Training Analysis and Design.
2. Course Development.
3. Collective Training Analysis and Design.

The discussions held with the training development personnel were in the format of open-ended interviews. Since the purpose of the interviews was to determine what items of information were used and how each was used, an open-ended question format was chosen over a more structured format.

In addition to interviewing training development personnel, standard course documentation and procedures for course development were reviewed. Each available document was evaluated to determine the nature of the decisions made, the user input information required, and the type of training specifications obtained. The characteristics of these documented processes were compared with standard ISD processes and outputs, as well as interviewee comments concerning decisions and processes. This comparison was done in order to identify aspects of the ISD processes relevant to the development of the TDDA.

The results of the interviews, output analyses, and technology reviews provided the basis for developing the conceptual model output and the gross model flow. In addition, the model was partitioned for further development. The partitioning helped to simplify the tasks of determining the extent to which the process under development had included all necessary steps and that all required data at each level had been considered.

Model Partitions

The TDDA was partitioned into segments for development as follows:

1. Processes/decisions for considering a single task
2. Processes/decisions for considering collective tasks
3. Cost evaluation

The overall model outputs identified were the following:

1. Task Training Prescriptions
2. Training Options
    a. Resident Training
    b. Extension Training
3. Cost Summaries

A detailed definition of these outputs and their processes was accomplished in accordance with the model development partitioning mentioned earlier.

Task Training Prescriptions

The training prescription definition and content were derived primarily from a consensus of opinions gathered from a review of ISD procedures and the expressed needs of course and materials developers. The agreed upon elements are listed as follows:

1. Training Algorithm
2. Stimulus Media
3. Presentation Method
4. Training Setting

Each of these is now discussed in turn.

Training Algorithm

A training algorithm is a process by which categories of tasks are most effectively taught. The algorithm prescribes a method for accomplishing the training, independent of the content of the task (i.e., stimulus, equipment, procedures, etc.) or of the training delivery system. The process specifies presentation activities, instructor decisions, student decisions/actions, and feedback requirements. Figure 2-1 illustrates a representative training algorithm.

Stimulus Media

This item prescribes the media through which the training material is presented. Stimulus media does not specify the student response mode except as a paper and pencil default condition.

Presentation Method

The presentation method prescribes the nature of instructor-student interactions. Some examples of typical presentation methods are conventional

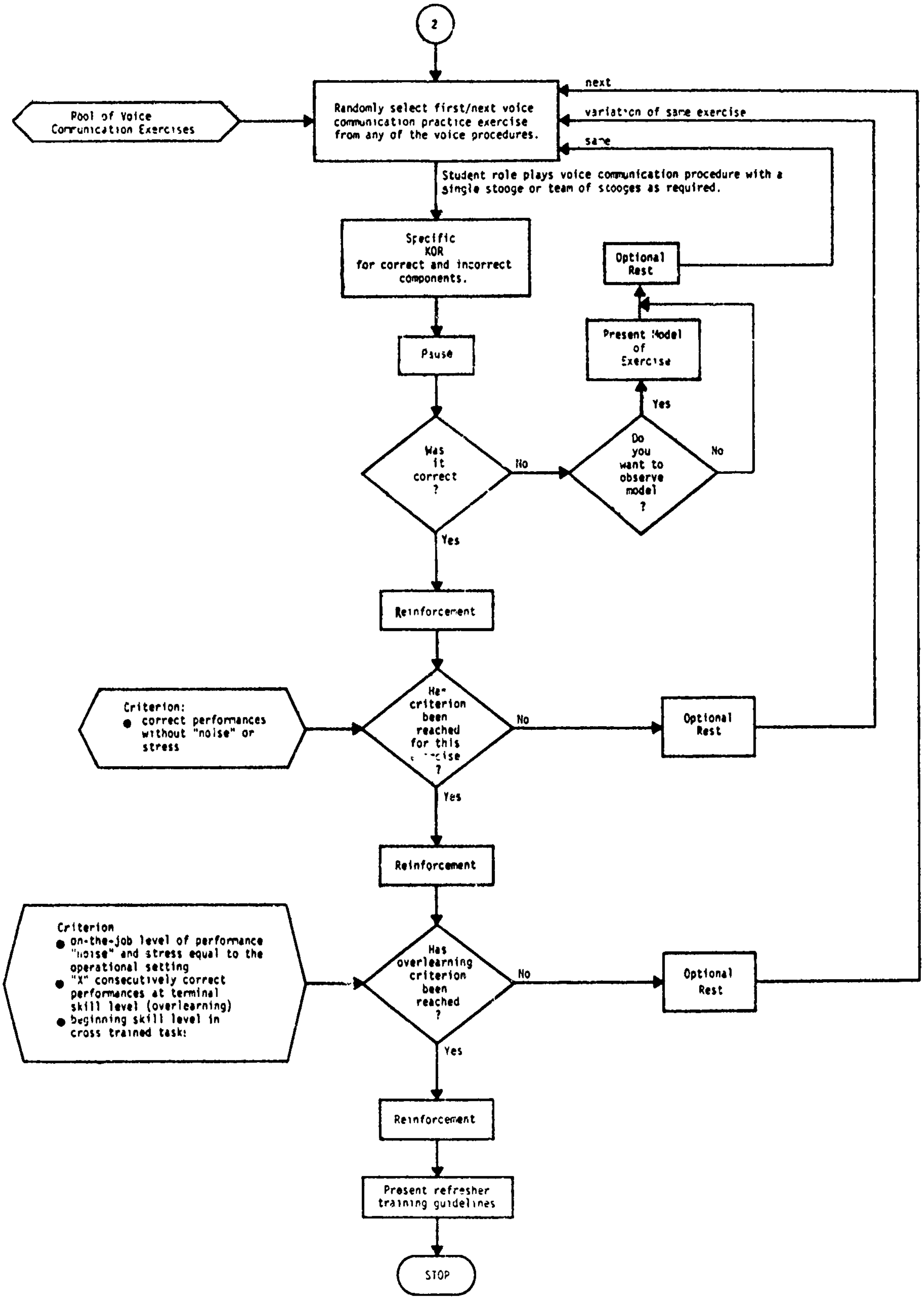


Figure 2-1. Sample Training Algorithm

lecture/demonstration, practical exercises, programmed instruction, peer tutor, and so forth. The presentation method differs from the stimulus media in that it specifies both the method for presenting stimulus information, as well as the nature of student-instructor interaction.

Training Setting

The training setting is usually derived from the presentation method. It simply describes the nature of the facilities required for taining. Class size has traditionally been the primary determinant of training setting.

Although the previous discussions were brief, it is clear that a missing element in training prescriptions developed previously concerns the nature of the student response. A critical aspect of any learning situation is the acceptance/evaluation of student responses, together with feedback on the correctness of the response. None of the elements incorporated in previous training developer aids takes the acceptance/evaluation of student responses into consideration. Therefore, an additional element was added to the list of training prescriptions specified in previous work. That element is the Response Acceptance Mechanism.

The output of the first model partition (i.e., considering one task at a time) was developed to prescribe the following elements for each task:

1. Training Algorithm
2. Stimulus Medium
3. Response Acceptance Mechanism
4. Training Method
5. Training Setting

The development of the decision processes for each of these elements was carried out in the following manner.

First, information and existing decision criteria present in the ISD procedures were noted. The steps in making a decision were diagrammed using conventional decision model representations. Information sources, decision points, decision criteria, and outcomes were all represented. In addition, decision and outcome rationale from the ISD process were noted on the diagrams. This first set of diagrams functioned simply as a set of working notes from which later versions of the conceptual model were developed.

The second step was to review the same or similar processes as presented in related literature. The original diagrams were checked against other processes in order to determine the consensus between methods. Where there were differences of consequence, the outcomes from the decisions were compared to determine whether modifications were required. Additions were made, or decisions were segmented, where precision was gained in the final decision process. In the case of direct conflicts (i.e., the same answer to a decision led to two different outcomes in the different techniques) the standard ISD process was maintained.

The third step was to review each of the decision processes for economy. This simply involved reordering the decision sequence to eliminate redundancies and/or to insure that the shortest path to a decision was taken. The final step was to restate the decisions for simplicity. Each of the decisions was developed in the form of a question or series of questions which could be answered either "yes" or "no."

The result of this process was a set of decision logic diagrams for selecting stimulus medium, response acceptance mechanism, training method, and training setting. The specific choices were essentially those of the ISD process, except in an abbreviated format that provided a much more usable process. The only new set of logic diagrams generated were those for the Response Acceptance Mechanism. A discussion of the development of this logic is presented later in this section of the report. The results for each of the elements is discussed next in their order of use in the model.

Training Algorithm Selection

The process of selecting the training algorithm was patterned after the approach outlined in TRADOC Pamphlet 350-30. Several changes were incorporated in order to more accurately match the training problems at hand to the proposed training algorithms. The verb lists were modified so that the verbs used in the TDDA were representative of an intersection of lists used in Navy material, previous Air Force material, and earlier versions of the Interservice ISD Procedures.

Basically, the process takes advantage of the fact that the verb used to describe a task indicates something about the nature of the task at hand and how to teach it. For example, in the task statement "run around the block", the task verb "run" indicates that the task is a gross motor skill. There is a general approach or a set of procedures which can be used to teach gross motor skills. This set of procedures is called a training algorithm. Altogether, 12 training algorithms for designing training for various tasks are currently defined by ISD. These are listed as follows:

1. Identifying Symbols
2. Verbal Chaining
3. Rule Using
4. Classifying
5. Decision Making
6. Problem Solving
7. Gross Motor Skills
8. Motor Chaining
9. Steering and Guiding Continuous Movements
10. Communicating
11. Monitoring
12. Attitudes

The approach of using the task verb to identify the type of training algorithm is basically sound. It was judged usable for this effort because the population of verbs used to describe tasks is small. All of the tasks in the machine ascendant MOSs will, in all probability, be described by a small, fixed set of verbs, each having a unique algorithm associated with it. That is, in the view of the task analyst each verb will have a single meaning. Verb lists of the type used in this model may not be generalizable across MOSs. For example, the verb list generated in this effort, although applicable to all Air Defense operator and maintenance MOS tasks, may not be usable for Medical MOS tasks. It is anticipated that work on refining the verb lists will continue throughout the life of the TDDA.

Stimulus Media Specification

The separate specification of stimulus medium and response mechanism was deemed necessary in order to more accurately characterize the nature of the tasks as related to the learning environment. This should enable the TDDA to more precisely determine the optimal training delivery system, including the instructional method and setting.

The process for specifying the stimulus medium was oriented to matching characteristics of instructional media to stimulus characteristics inherent in a task. This approach was used to provide as much fidelity in the stimulus representation as possible. The questions incorporated into the model were designed to be answered in a way representative of the job environment.

At present, the process requires the user first to identify the class of media inherent in the task under consideration, and then to describe selected details of the stimulus. The stimulus characteristics questions were posed at a level of detail requiring the training developer (TD) to consider all stimulus "displays" or sources in the task. In addition, the TD is required to characterize the stimuli at a level representative of task stimuli as a group. On the basis of the derived information, the decision process prescribes a stimulus medium appropriate to training the job stimulus.

The classes of stimuli used in the TDDA are the following:

1. Verbal
2. Audio
3. Visual
4. Audio-visual
5. Tactile

This set was judged to be exhaustive of the classes of stimuli likely to be encountered in an equipment-related MOS. In the case of identifying the classes of stimuli in the job environment, only one class is identified for a single task. This assumes that each task normally involves only one class of stimuli. Since there are instances of audio and visual stimuli being present in a single task, a combined category was also developed. In most other instances, a single stimulus class represents the primary class of task stimuli.

The single exception to the above rule involves equipment-related tasks in which the performer follows technical manual (TM) procedures (e.g., verbal stimuli) in performing a task which utilizes equipment indicators. Although the technical manual procedures present a stimulus for each step in the task, the stimuli of major interest to the task performer (i.e., the stimuli evaluated, acted upon, used for a decision, etc.) are the equipment indicators. This approach does not exclude the use of technical manual procedures as task stimuli, since tasks specified as "locate the troubleshooting procedure in the TM" or "follow the alignment procedure in the TM" are perfectly legitimate for the purpose of teaching or evaluating students in the use of TM procedures.

The question set for each class of stimuli were developed in an operational fashion. First, the population of media generally recognized as usable for presenting each class of stimuli was listed. Once listed, the media were rated for their ability to present various stimuli within the class. The presentation techniques considered were those reported in the literature and known to the project staff. For example, two techniques considered for the audio-visual class were color slide-tape and color film strip-tape. In this example, the fidelity of the two techniques were judged equivalent, but one was more amenable to changes in visual content. However, no consideration was given to sizes of slides (i.e., super slides, 35mm single frame, 35mm double frame, or mini slides) or sizes of filmstrip (i.e., 35mm, 16mm, and Super 8mm). Also, no consideration was given to type of tape (i.e., reel-reel, cassette, 8 track, or sound on slide).

Considerations of the means for implementing the techniques selected are constrained more by the quality of available local support for materials development, and by the presentation equipment on hand than by theoretical issues like fidelity.

Once the fidelity ratings were completed, the list for each class was reviewed to ensure that there were no duplications and that all desirable techniques were included. Next, a question set which discriminates between the techniques on the basis of relevant characteristics was developed. No attempt was made to build an exhaustive question set for delimiting all characteristics that might be theoretically important at some point. The set developed for each class consisted of those questions necessary and sufficient for discriminating between the techniques usable for the class. The resulting question set is presented below in Figure 2-2, Stimulus Questions.

Figure 2-2

Stimulus Questions

1) Are the visual stimuli in color.
2) Are the stimuli equipment indicators.
3) Are the audio stimuli voice sounds only.
4) Are the stimuli visually distinct (not obscured or overshadowed by peripheral stimuli).
5) Are the movements continuous (not ON or OFF).
6) Are the verbal stimuli audio.
7) Are the stimuli frequently changed or updated.
8) Are the stimuli solid objects (3-dimensional).
9) Are there many ambient (surrounding) sounds.
10) Are the ambient sounds random (not cyclic or periodic).
11) Are the audio stimuli generated by the equipment.
12) Do the stimuli move.
13) Will performing the task wrong result in damage to system equipment.
14) Is the system equipment operational at least 75% of the time it is required for use.
15) Is the task a maintenance task (as opposed to an operator task).

Response Acceptance Mechanism

The decision process for determining the response acceptance mechanism for training was developed in essentially the same way as that for the stimulus medium. That is, the classes were first identified, next the techniques for accepting responses within each class were listed and rated for fidelity, and finally a set of "yes-no" questions were developed in order to discriminate between alternatives within each class. The difference is that, unlike the stimulus media selection process, the selection of the response acceptance mechanism for the training environment has not been widely performed or described.

The classes of response types were identified first, just as was done for the stimulus classes. Because less work had been done on response types than on stimulus classes, the population of response types was found to be somewhat more restricted. The response classes identified are listed as follows:

1. Equipment Manipulation
2. Voice
3. Written
4. Body Movement

The simplifying element, which provides the basis for these four classes, is that each represents a group of overt actions that indicate that a task performer has completed an action. They were selected to represent the means or mechanism through which a task performer's responses are detected, accepted, and evaluated. It is essential that the classes developed deal with overt responses.

Consideration was also given to other response acceptance classes. However, there was no acceptable way of evaluating mediating processes directly. Only overt responses or actions can be detected, accepted or evaluated. For example, in a troubleshooting task there is no direct way to detect and evaluate troubleshooting activities. What can be detected, accepted, and evaluated are the task performer's overt actions (e.g., setting the equipment controls, reporting indicator readings, or replacing elements of the equipment). The overt actions of the task performer indicate that the troubleshooting task was performed correctly.

The response acceptance classes were developed by first listing samples of responses made in the various equipment tasks (e.g., alignment, adjustment, servicing, operating, troubleshooting, repair, removal, and transporting). The responses were next grouped. Each response group was then characterized as to the class of response acceptance mechanism involved. Once the groups containing mediating processes were eliminated and the responses were classified in terms of overt responses, the four classes listed previously were all that remained. Other classes may be included as the TDDA is developed, but the initial attempt at specifying the response acceptance mechanism appeared to be adequately served by these four.

Unlike the situation with stimulus classes, tasks can be characterized in terms of more than one type of response. While stimuli from one class can be represented by a member of another class, this is not true for responses. There is no way to accept or evaluate a written response if the only class of response acceptance mechanism included in the training environment is equipment manipulation. Therefore, the process for selecting response acceptance mechanisms was designed to have more than one class of response listed as being acceptable for a task. This was necessary to insure that the response acceptance mechanism(s) selected for a task could receive all responses made by a trainee.

Once the classes were identified, the mechanisms currently available for accepting and evaluating each class's responses were listed. As with the stimulus media selection process, a set of questions which discriminate between items within each class was developed. Again, no attempt was made to develop an exhaustive question set which would elaborately characterize all the responses in the class. The question set developed is that which is necessary and sufficient to discriminate between the response acceptance mechanisms for use with tasks in each class. The abbreviated question set developed is presented below in Figure 2-3.

Figure 2-3

Response Acceptance Questions

1) Is the task a maintenance task (as opposed to an operator task.
2) Are the manipulations discrete. (separate and distinct)
3) Are the control displays of the equipment completely nonlinear.
4) Will performing the task wrong result in damage to system equipment.
5) Is the system equipment operational at least 75% of the time it is required for use.
6) Are the responses mainly names and locations.
7) Does he respond by giving instructions or orders to a group.
8) Do the responses require interaction with others.
9) Does the task performer evaluate his own response.
10) Are responses mixed, selected and constructed.
11) Are some of the responses selected but mostly mixed.
12) Are the responses written on a form.
13) Does he respond to voice instructions.
14) Are the responses coordinated group performance. (give instructions to group)

Presentation Method Selection

The development of the process for selecting a presentation method was performed somewhat differently than the development of the previous two elements. Methods used for presenting training must support the requirements imposed by the stimulus media and response acceptance mechanisms. Since the stimulus media and response mechanisms are unique to a task, the method must also be selected task by task. It is not sufficient to decide ahead of time which method will be used for training, and then try to make other elements conform to that choice.

The methods used in a training environment have certain characteristics which prescribe or limit the nature of instructor-student interactions. In addition, the stimulus media and response acceptance mechanisms utilize or prescribe certain characteristics of the instructor-student interaction. Thus, the probelm for development of the process of selecting the training method is one of mapping the characteristics required by the stimulus and response choices onto the characteristics of the training methods.

The methods identified for possible use in a military equipment training environment were those currently available, as well as others judged potentially useful. The complete list of training methods used in this project is as follows:

1. Case Study
2. Computer Assisted Instruction
3. Demonstration
4. Games
5. Group Interview
6. Guided Discussion
7. In-Basket Exercise
8. Peer Tutor
9. Programmed Instruction
10. Programmed Practical Exercise
11. Role Playing
12. Study Assignment Book
13. Traditional Classroom
14. Traditional Practical Exercises
15. Tutoring

Although some of the above training methods will probably never be used, all were included in order to provide an opportunity for evaluating their potential usefulness. Methods which are inadmissible can later be removed from the list of available choices.

The list of the stimulus media and response acceptance mechanisms included in this effort were as follows:

Stimulus Media	Response Acceptance Mechanism
1. Audio Tape	1. Audio Tape Recorder
2. Books with Questions	2. Books with Questions
3. Microfiche or Film	3. Group Instructor
4. Mockup	4. Mockup
5. Movie	5. Question Set
6. Printed Text	6. Real Equipment
7. Programmed Text	7. Simulator
8. Real Equipment	8. Teaching Machine
9. Silent Film Strip	9. Tutor
10. Silent Slides	10. Video Recorder

11. Simulator
12. Sound Film Strip
13. Sound Slides
14. Television

Identify Characteristics

The first problem was that of identifying the relevant characteristics. This was viewed initially as a two part problem. First, the characteristics relevant to both stimulus media and method were examined. Second, those for both response acceptance mechanisms and method were considered. This approach was taken because the project staff was not convinced that the two sets of characteristics were the same. By considering them separately an effort was made to maximize the chance that differences, if they existed, would be identified.

To determine which characteristics of the stimulus media and method were related, each stimulus medium was listed under the method for which it was judged applicable. Once each of the lists was completed, the media listed under each method were compared to determine which characteristics of the media related to their application to the various methods. The characteristics of the stimulus media which were judged important are the following:

1. Pacing controller
2. Stimuli content
3. Next learning activity

Originally Type of Feedback was also considered, but it became obvious that this characteristic related to the response/method area and not to stimulus/method.

Classify Media and Methods

In terms of the pacing controller, two characteristics were identified: student and program. The characteristic "program" requires some explanation to be understood completely. The pacing of stimulus materials is considered program-controlled when the learner does not have the option of speeding up or slowing down the pace in the normal application of that medium. For example, a television stimulus medium provides the student no control over its rate of presentation, even when the material is on tape. The rate at which new items are introduced (i.e., the pacing of the stimulus media) is controlled by the program. Although in some cases where the student has control of the television tape player, the repeating of segments of the presentation is possible; still, only minor changes in pacing can be achieved. Media with these characteristics are classed as program controlled; media which are normally either student or program controlled are classed as neither. Media where no pacing control is implicit (e.g., a book) are classed as "student controlled."

The next classification considered was stimulus content. The variables identified were (1) Visual, (2) Verbal, and (3) Audio. Verbal content is defined as being spoken or written English (or other) language or numbers. The stimulus content classed as visual are non-language or numeric visual items (e.g., meters, equipment, schematics, parts breakdown drawings, etc.). Variables classed as audio are equipment or environmental sounds other than spoken language or numbers.

The "next activity" characteristic emerged primarily because it is a factor on which training methods differ. This characteristic has no intrinsic relation to any of the other stimulus media considerations. Next activity is defined as the mechanism that controls the sequence of the items presented through the stimulus medium. The three mechanisms for sequence control are defined as (1) program, (2) instructor, and (3) student. Next activity is considered program controlled when the student can not easily change or select the sequence in the normal application of the stimulus medium. It is classed as controlled either directly or indirectly (by assignment) by an instructor or third party when the presentation is under another person's direct control. When what is presented next is normally controlled by the student, the next activity is classified as student controlled.

Once each of the media were classified, the methods commonly available in the military training environment were listed and characterized in terms of the pacing controller, stimulus content, and next activity. On each of these dimensions, the methods were classified in accordance with their normal usage. For example, traditional classroom was given the following classification:

1. Pacing Controller--Instructor
2. Stimulus Content--Verbal, Visual
3. Next Activity--Instructor

At this point, each of the media and methods were characterized on the same three dimensions for a given stimulus medium. The method(s) which best support each medium is determiend by finding the method whose characteristics most closely match those of the medium.

Classify Response Acceptance Mechanisms and Methods

An identical process was followed for identifying the response acceptance mechanisms. Four characteristics, instead of the three used for the stimulus media, emerged. These characteristics are:

1. Pacing controller
2. Type evaluation
3. Feedback
4. Next learning activity

Two of the characteristics are the same as those used with the stimulus media, pacing controller and next learning activity. The values for pacing controller for response acceptance are (1) student, (2) instructor, and (3) program. The instructor controls the rate of response acceptance for one mechanism, that of group instruction. In all other cases, the controller of the rate at which responses are accepted is either the program or student. The next learning activity dimensions are (1) program, (2) instructor, and (3) student, the same as they are for the stimulus media.

Type of evaluation was included to identify the types of responses which are possible within each of the mechanisms. The types considered were selected and constructed. Responses are called selected if the student does one of several actions which are known to him in advance, and where his choices are restricted to a small population at any one time. Responses are considered constructed if the student is free to do any of several actions, any or all of which might not be known to him in advance. The critical discrimination is whether or not the student chooses a response from a small restricted population of known responses or whether he is free to produce or invent a response.

Feedback is considered a two-dimensional characteristic which can vary both in immediacy of feedback and feedback source. The two values for immediacy are immediate and delayed. A response acceptance mechanism is classed as providing immediate feedback if no delay is experienced before the feedback is provided. If the student has to make two or more responses before feedback on the first response is provided, the mechanism is classed as providing delayed feedback. In addition, feedback is classed as either intrinsic or extrinsic. A response acceptance mechanism is classed as providing intrinsic feedback if the act of making a correct response is evident through continuation or advancement to the next activity. However, if a separate mechanism for providing the feedback has to be incorporated in the response acceptance mechanism (e.g., a frame which says "you were correct" or the instructor saying, "correct") then it is classed as providing extrinsic feedback.

Once the characteristics were defined, each of the response acceptance mechanisms and each of the methods were examined and classed on each of the characteristics. Like the stimulus media/method comparison scheme, the response acceptance/method evaluations consisted of comparing the characteristics of the selected mechanism with those of the methods to determine which method best supported the response acceptance mechanism. Final selection of the training method was developed to use a composite of the two evaluations. The method recommended by the process is the one which best satisfies the three characteristics of the stimulus medium and the four characteristics of the response acceptance mechanism.

Method/Algorithm Agreement

In the process of applying the above techniques, it became obvious that presentation method related to more than the stimulus media and response acceptance mechanisms. Methods also relate to the training algorithm used for the task. Examination of the training methods and algorithms showed them to be related in at least one specific way. This was the type of feedback which could be provided by the method, and the immediacy of that feedback. The process developed for determining whether or not a method and algorithm are compatible was the development of a list of methods which are compatible with each of the algorithms.

This approach appeared to be a reasonable first attempt based on preliminary tryouts. In most cases, the only time an incompatible algorithm and method occurred was when the task verb was inappropriate. That is, in cases where the task verb depicted a duty and not a task, and the stimulus and response characteristics did not fit the verb. Therefore, the process of verifying the adequacy of the method through comparison with the algorithm provides checks in the model which indicate to the training developer that he has made one of two errors: He used a verb which is too large in scope (i.e., a duty verb instead of task verb), or he answered the stimulus/response logic questions in a way which does not coincide with the task type indicated by the verb. Obviously, the indicator is quite gross, since the mechanism for its operation operates at a very general level.

The checks and balances described previously were not designed to be sensitive to minor variations in the stimulus media and response acceptance mechanism decision outcomes. This was deemed desirable since the choice of algorithms is performed at a level which does not recognize minor variations within types. The types of inconsistencies detected are those which are inconsistent in their application, since the training methods are inappropriate for the type of task being learned. These errors are selected in the early portion of model application and training specification development and can thus be revised. Also, errors are not allowed to proceed undetected through the remainder of the process into material development activities.

The process is designed so that once an inappropriate method for the selected training algorithm is chosen the training developer has to re-evaluate the verb used to describe the task/algorithm and then the answers to the stimulus response question in the decision logic process. Although this represents a fairly gross remedial activity, it is anticipated that requiring the training developer to review the selection of the verb and the responses to the stimulus and response questions will be adequate, since the error should be obvious once it is detected.

Training Setting Selection

The final element in the training prescription is the specification of the training setting. Initial development of this aspect was accomplished by preparing a matrix of all possible training settings and the methods, media, and mechanisms with which each can be used. The result of this effort was a much more detailed specification for training setting that is useful to training developers, thus a second approach was taken.

The training settings commonly available in the military training environment were listed. These included the following:

1. Small team site
2. Large team site
3. Individual carrel
4. Small group carrel
5. Traditional classroom

Once the training sites were listed, the variables for choosing between them were developed. After the characteristics of the setting were listed, three items of interest which would discriminate between the settings were identified. These items are listed as follows:

1. The number of students involved (small number versus 10 or more)
2. The nature of student interactions (individual versus team)
3. Whether or not equipment manipulations are required (equipment tasks versus non-equipment tasks)

This second approach to selection of the training setting simplified the logic required to reach a decision usable by the training developer. In addition, it provided results at an appropriate level of detail, and in terms of training settings with which the training developers are familiar. The resulting decision logic process for selecting the training setting is presented in Figure 2-4.

Training Prescription

The entire development effort described previously leads to a training prescription which includes the following elements:

1. A training algorithm for the task
2. A stimulus medium to be used in training the stimulus element of the task
3. A response acceptance mechanism to be used in accepting, evalauting, and provididng feedback for the task response set
4. A training method which would support the stimulus medium and response acceptance mechanism required for the task
5. Verification of the method for the training algorithm initially selected on the grounds of the task verb
6. A training setting in which the task would be learned

Initially, the prescription-generation process was developed in terms of a conceptual or ideal model which could later be translated into an actual set of forms and procedures to be used by training development personnel. However, during the early stages of development, every effort was made to develop the conceptual model in the context of the situation in which the model would later be applied. Therefore, elements like the task verbs were based on those encountered in Soldier's Manuals and task descriptions currently prepared by the Army. With minor exceptions, the stimulus medium items and response acceptance mechanisms included in the decision processes are also representative of those currently in use or available to Army schools. Similarly, the methods and settings are those familiar to training managers and instructors currently involved in Army training activities. Some aspects of initial model development are only peripherally related to the current training environment. These elements were included in the validation version of the model so that their relevance and importance for continued inclusion could be evaluated.

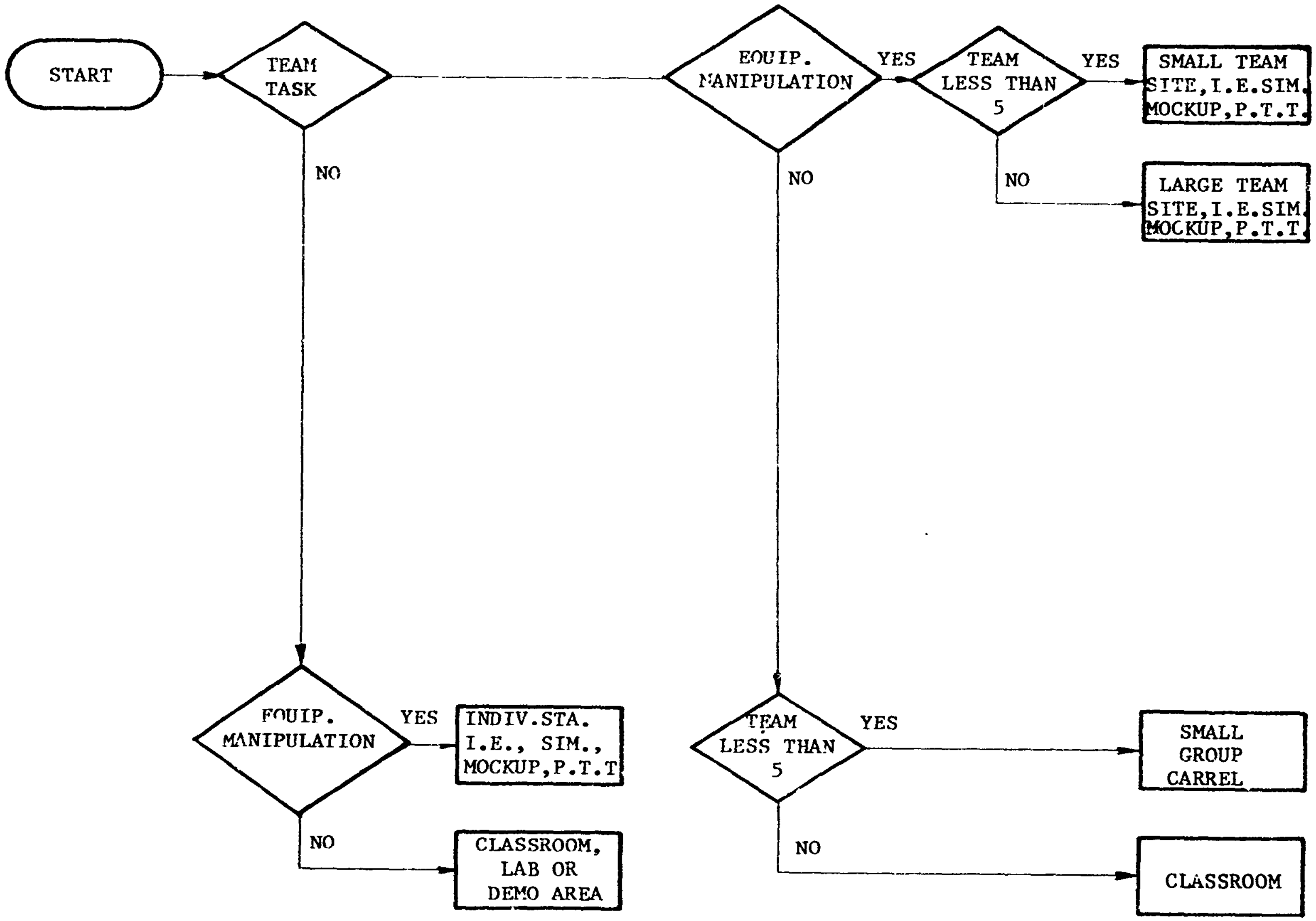


Figure 2-4. Training Setting Decision Logic

The portion of the model completed at this point is that dealing with each task independently. The two remaining portions of the model are (1) the portion dealing with the collection of tasks for determining training course sequence and (2) the portion dealing with cost considerations. These two topics are addressed in the remainder of this section of the report.

Training Options

Overview

The second partition of the model deals with collective tasks. The objective of the second partition is to determine which tasks should be taught in initial training (i.e., resident courses like Advanced Individual Training), which tasks should be taught on the job (i.e., TEC lessons or formal OJT), and which tasks should receive no training. For purposes of development in this partition, the Enlisted Personnel Management System (EPMS) for operators of Air Defense systems was assumed to be the target for which decisions were being made. This assumption was made to provide a complete training cycle which had stated criterion objectives in the form of a set of tasks to be mastered. In addition, a criterion-referenced test, the Skills Qualification Test (SQT), was available to measure individual soldier proficiency on the task set at the end of the initial training and job performance period.

Early in the development of this partition, the need for a way of assigning a training priority to each of the tasks was recognized. Although all tasks must be learned, not all tasks have the same importance in terms of their criticality for job performance. In addition to a priority rating, other elements were judged to be important in determining which tasks were assigned to each of the training categories. These elements include the following:

1. The pay grade of the task performer
2. The system equipment on which the task is performed
3. The support equipment used in the performance of the task
4. The task dependencies based on the skills inherent in each task

Pay grade of the task performer was included because it provides a good estimate of the number of months the task performer will have been in the Army prior to being required to perform a task. This is particularly true for the early portions of an individual's military career as exemplified by EPMS Level-1 personnel. The lower the pay grade the sooner after basic training and initial resident training the individual will be required to perform the task. In addition, it was felt desirable to consider the total population of tasks to be performed in the Military Occupational Specialty (MOS) at each of the pay grades. This would permit determination of the proportion of pay grade tasks trained in each training category (i.e., initial resident, on-the-job, and no training).

The elements of system equipment/support equipment were included for reasons similar to those of pay grade. Alone, the elements provide a way of determining the proportion of tasks in an MOS that are performed on each piece of system equipment and the proportion that requiare the use of each piece or combination of pieces of support equipment. Therefore, tasks can be selected for the various training categories on teh basis of which system equipment and support equipment items used in the largest proportion of MOS tasks. Although the elements provide an adequate decision basis separately, their power is expected to be best utilized through their interaction. That is, when the tasks are listed in terms of the combinations of pay grade, system equipment, and support equipment it is anticipated that more accurate decisions concerning assignments of tasks to training categories will be possible.

The final decision element, task dependencies, was incorporated to permit refinements in the assignment of tasks to training categories and to provide task training sequence information. The types of dependencies viewed as most useful are the skill dependencies. That is, a task which involves a single or small number of skills which are a subset of a larger more complex task will have larger tasks listed as dependent on it. These skill dependencies provide a means of establishing necessary prerequisite ordering of the tasks for a training program. Once this portion of the process was defined, the conceptual elements of the model for determining what is to be taught were considered complete. The next phase of development involved devising a process which would provide meaningful information on each of these elements.

Development of Training Task Matrix

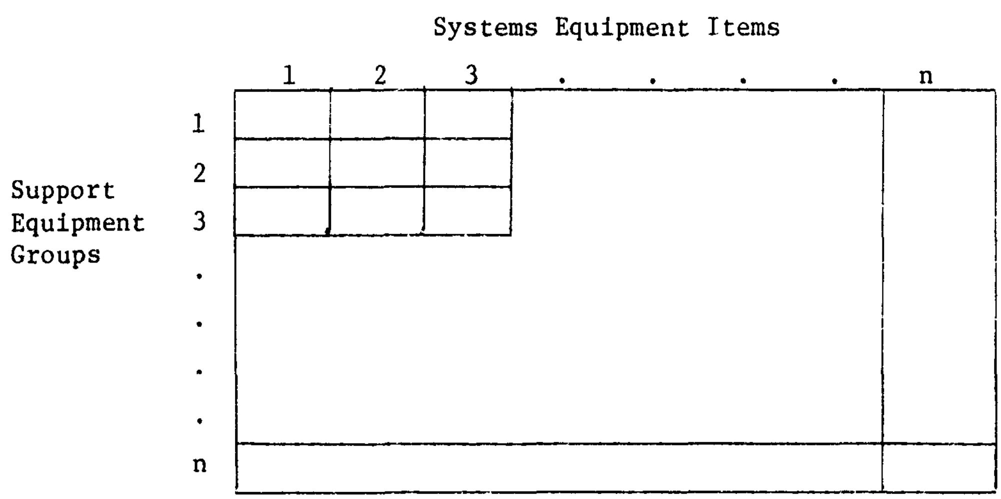
A matrix representation was chosen in order to facilitate the presentation of the large amount of necessary information on the form of the MOS tasks. The initial form of the matrix was three-dimensional, with the dimensions being:

1. Pay grade
2. System equipment
3. Support equipment

Considering the Pay Grade dimension as the z-axis of the matrix or "slice" of the matrix, each slice is identical in form and is similar to the matrix shown below in Figure 2-5.

Figure 2-5

One Slice of a Training Task Matrix



System equipment items are specified as the single equipment items on which a task is performed. This provides a number of columns in the matrix equal to the number of separate pieces of system equipment on which tasks are performed. However, there may be empty cells in the columns for a given slice (i.e., pay grade) of the matrix. Some pay grades may not perform tasks on some of the equipment items.

Support equipment groups are utilized because tasks performed on an item of system equipment frequently require combinations of items of support equipment (e.g., test equipment and/or other system equipment items). Using support equipment groups insures that a task will not appear in more than one cell of the matrix. Using individual support equipment items would cause a task to be listed in each cell of the various support equipment items used for the task. In order to be consistent, each support equipment group is defined as a unique combination of support equipment items (i.e., a subset of one group constitutes a different group).

Each cell of the Training Task Matrix is specified to contain the list of tasks performed on the system equipment indicated, using the support equipment represented by the group. In addition, the task dependencies and training priorities are to be appended. Therefore, a typical cell entry is similar to that presented in Figure 2-6.

Figure 2-6

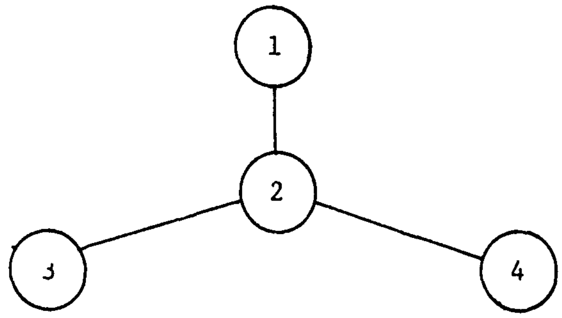
One Cell of the Training Task Matrix

Task	Dependency	Priority
1	2	1
2	3,4	1
3	-	2
4	-	3

Using the dependencies presented, the decision maker can draw a pictorial representation of the task relationships showing the skill hierarchy. The skill hierarchy for the task illustrated in Figure 2-6 is shown in Figure 2-7.

Figure 2-7

Example of a Skill Hierarchy for Tasks in One Cell



No representation of skill dependencies between cells was considered since crossing cell boundaries was felt to constitute entry into independent areas. For example, two sets of tasks performed on one piece of system equipment using two different groups of support equipment are considered to have only minimal skill relationships to one another. The one exception to this general condition is when one group of support equipment is a subset of the other; however, experience has shown this situation to occur very infrequently. Since there are no identical actions for similar steps, tasks performed on one piece of system equipment tend to be unrelated to those performed on another piece. The only exception to this rule is when two pieces of equipment are nearly identical in terms of controls and displays, and their functions are very similar. In this case, the tasks performed on the two pieces of equipment might be nearly identical and it may be sufficient to list only one of the equipment items rather than represent skill dependencies between cells for the equipment and support items.

Tasks for different pay grades (i.e., skills crossing slice boundaries) were considered to be a somewhat more complex problem. Where task types remain the same (e.g., operator tasks) there are definite skill dependencies. However, the fact that they are performed by different pay grades represents a time distance between the performance of the tasks. There is some question as to whether such dependencies are relevant to decisions concerning which tasks to include in an initial resident course. These dependencies were judged to be of secondary importance, but they might be used to resolve situations that involve "ties", where both tasks cannot be trained due to cost or time constraints.

The other class of tasks performed on the same system equipment item using the same support equipment group by different pay grades is those in which task types differ (e.g., E-2 operator tasks versus E-3 maintenance tasks). For these tasks, the set performed by the lower pay grade represent a subset of the tasks of the higher pay grade. As with the tasks described immediately above, the skill dependencies are not those given primary consideration when selecting the tasks to be included in an initial resident course. The final primary element to be considered is the priority of the tasks for inclusion in initial training. This element is sufficiently complex in its development to warrant a separate discussion.

Development of Task Training Priority

The development of a technique for determining the training priority of a task has been a sought after goal for some time. No attempt was made in this project to generate a universal indicator. However, a technique was developed which uses system information specifically available for each MOS. Development of the prioritizing technique was very straightforward and involved essentially three steps as follows:

1. Identifying the variables
2. Scaling the variables
3. Developing the function

These are discussed as follows.

Identifying the Variables

The process of identifying the variables can be characterized as being an iterative procedure where the most critical consideration is identified at each point. The first iteration is concerned with the most important variable. In essence, the question is: "If you could know only one item of information about a task in order to determine whether to include it in initial training, what would that item be?" As might be expected, many alternatives are considered. Each alternative for each iteration is compared with each of the other alternatives to ensure that each has a unique contribution and none are duplicated.

The item chosen as the most important is an indicator of how long after initial training the soldier will be expected to perform the task. Since the model was being developed for EPMS Level-1 Personnel, it was decided that a good indicator of this item is the pay grade of the task performer. The pay grade indicator was chosen for several reasons. First, in the early pay grades the time period to the next pay grade is reasonably constant. Second, the time period is not subject to changes except in cases of gross misconduct on the part of the soldier. Third, the item is obtainable from operational personnel since tasks/positions are assigned on the basis of pay grade. Fourth, manning an operating unit is specified in terms of the number of personnel of each pay grade in an MOS assigned. The fact that each advanced individual training (AIT) class is likely to have several persons who re-entered the Army as E-3s or E-4s is not considered. The average time period associated with the initial four pay grades in Air Defense MOSs is as shown in Table 2-1.

TABLE 2-1

Average Time in Grade

Rank	Average Time in Grade
E-1	Approximately 2 to 4 months after enlistment
E-2	Approximately 4 to 8 months after promotion (during initial resident training)
E-3	Approximately 6 to 12 months after promotion
E-4	Approximately 8 to 16 months after promotion

Therefore, using the pay grade as the indicator of how long after initial training a soldier will do a task gives a reasonably good estimate of the time to performance. The longer the time period the less important it is that a task be included in initial training.

The second most important fact to consider in selecting a task for inclusion in initial training was judged to be the contribution of the task to the system's mission. For example, if two tasks are tied with respect to the rank of the performer, then the task with the most impact on the completion of the mission should be included. The Field Manual (FM) for each of the Army's air defense systems lists the system operational readiness condition for each of the system item. Thus, the variable chosen to represent system readiness was the operational readiness rating. This rating shows the system as "green", "amber", or "red." The further scaling of this factor is described later in this section.

The last three priority factors identified were considered to be of approximately equal importance. These factors are listed as follows:

1. Time to application and task learning time
2. Percentage of members performing
3. Percentage of time spent performing

The emphasis in the Time to Application factor is the length of time after a new graduate arrives in the unit that he will be expected to perform the task. The second portion of this factor, Training Time, refers to how long it will take a trainee to master the task in a one-to-one tutorial environment. This factor then represents the importance of the task for training based on how soon it must be performed, and how long it takes to train the task in a tutorial environment.

The remaining two priority variables, percentage of members performing and percentage of time spent performing, are obtained from Comprehensive Occupational Data Analysis Program (CODAP) information on the MOS. The percentage of members performing a task was judged to be important in selecting tasks for inclusion in initial resident training. Additionally, the percentage of time spent by the members performing was judged to be relevant.

In general, the importance of each of the above variables is reflected in the order in which they are mentioned. The tasks given greatest considera-tion for inclusion in initial MOS training are those performed by the lowest pay grade. The second ranking consideration is the impact the task has on the system's operational readiness. The third level of consideration involves time to application, training time, the percentage of members performing, and the percentage of time spent performing.

Scaling the Variables

The next project activity involved scaling the priority variables and developing their functional relationship. Although these activities were performed simultaneously, they are discussed separately for the sake of clarity.

The nature of the priority variables was such that the data on each occurred in clusters. Thus, a decision was made to develop a scaling procedure which takes advantage of natural task groupings. In the case of the pay grade of the performer, the groupings are obvious; however, the scale value to place on the groupings is not. Although several initial scaling attempts were made, the one chosen for tryout supported the following philosophy: The tasks performed by each lower pay grade are twice as important in terms of their inclusion in initial resident training as the tasks in the next higher pay grade. Although the average time after the initial training for each pay grade is not quite twice that of the next lower pay grade, it is quite close. In addition, since skills decay over time in a non-linear fashion, a ratio relationship seemed reasonable. Another remaining problem was where to anchor the scale.

The basic rationale proceeded as follows. Any task not expected to be performed by a pay grade acquired within two years following initial training will show no benefit from being included in initial training. Therefore, all tasks performed by the E-6 pay grade are given a rating of zero. Since two multiplied by zero is still zero, the next problem was to select the rating to be given to tasks performed by E-5 personnel. A decision was arbitrarily made to use a rating of 0.5. Therefore, E-4 tasks assume a rating of one, and E-3 tasks receive a rating of two. No rating was given to E-2 or E-1 tasks because most air defense personnel are E-3s when they arrive at their first duty station. This is a result of the length of their initial resident training courses. A decision was made to include E-2s and E-3s in the same category to allow for exceptions in regular assignment practices. The final pay grade rating scale used for developing the functional relationships is shown below in Table 2-2.

TABLE 2-2

Pay Grade Ratings

Tasks Performed By	Scale Value
E-1, E-2 or E-3	2
E-4	1
E-5	0.5
E-6 or higher	0

The rating scale for operational readiness was difficult to determine. No simple procedure was apparent from the information included in the system readiness categories. However, the non-performance of a task which causes the system to be red or inoperative is more important than a non-performance that causes the system to be amber or partially operative. In addition, tasks representing these two system states are judged to be more than a single step above tasks which when not performed leave the system in a green readiness state. Therefore, the initial scale values chosen for each of the readiness classes are as follows:

1. Green--1
2. Amber--3
3. Red--4

A scale value of "2" was not assigned to amber because it is assumed that the ratings, once assigned, will be combined to produce a total score, and it was judged desirable to rate amber more than one point higher than green. Green tasks are assigned a scale value of "1" because these tasks have some importance for system operation, even if the system readiness condition does not change when they are not performed.

The scale for time to application is based on the amount of time that a soldier will be in the unit before training can be initiated. Any task which has to be performed during the first month on the job is judged assignable to AIT. If the task is to be performed during the second month, it is judged potentially assignable to OJT. Tasks requiring two or more days for training in the first month are questionable because of potential scheduling problems in the units. If a task requires less than two days to train, its chances of being trained during the first two months is judged better. Finally, a task which is to be performed after the initial two months, regardless of training time, is judged amenable to training in OJT.

The ratings given to time to application and training time are those as shown below in Table 2-3.

TABLE 2-3

Ranking of Application and Training Time

Time to Application	Training Time	Scale Value
4 weeks or less	-	4
5 to 8 weeks	2 days or more	3
5 to 8 weeks	Less than 2 days	2
More than 8 weeks	-	1

The scale values were developed to reflect the importance of the tasks for inclusion in initial resident training. The values are inversely proportional to the probability that a task will be trained in OJT before the task is expected to be performed. Again, a value of zero is not used because there are no tasks that have zero importance for inclusion in initial training.

The scale developed for percent members performing and percent time spent are based on equal intervals of the percentages reported in the CODAP data. The CODAP printouts for the MOS selected for this development effort were examined to determine the number of cases falling within each range. Ranges were marked off so that approximately one-fourth of the total sample fell in each class. The resulting scale ratings are shown below in Table 2-4.

TABLE 2-4

CODAP Ratings

Percent Members	Percent Time	Scale Value
70 and above	.75 and above	4
40 - 69	.59 - .74	3
20 - 39	.25 - .29	2
0 - 19	.01 - .24	1

Developing the Combination Function

The development of the combination function was carried out in two steps. First, a relationship between the rating scales was established. Then a scaling technique was developed that would produce training priority ratings in the range one to five.

It was initially decided that since no combination function was apparent, an additive relationship for the five variables would be assumed. That is, the values taken by each of the variables would simply be added together to produce a total score. When this was done, two things became apparent: First, the pay grade of the task performer did not have a ratio effect on the total, even when its values were in a two fold relationship to each other. Second, the Operational Readiness factor was no more important to the toal score than the other variables. To remedy this situation, two actions were taken. First, the values of the Pay Grade factor were used as a multiplier for the sum of the other four variables. Second, the values for the Operational Readiness factor were changed from one-three-four to two-four-five, respectively. Although shifting the lower value from one to two had only minimal effect, shifting the upper value from four to five put the scale values for operational readiness above the limits for the other three variables, which are of lesser importance.

One additional benefit resulted from the above modifications: The range of the resulting priority values was extended. The amount of "overlap" in rating values for the different pay grades was also reduced. The final form of the priority combination function is as follows:

Priority Rating = Pay Grade X (Operational Readiness + Time to Application + Percent Members Performing + Percent Time Spent)

The range of the combination function is from 0 to 34. This range was judged too broad for real-world use, and was thus considered unusable. Thus, a decision was made to group the scale values into five categories and assign a priority score of one to five to each of the resulting categories. The range of scale values included in each priority category was chosen to minimize the number of pay grade overlaps between categories. The resulting ranges are those shown in Table 2-5.

TABLE 2-5

Training Priority Categories

Combination Function Value	Priority Score
22 - 34	1
14 - 20	2
8.5 - 13	3
5.5 - 8	4
0 - 5	5

Cost Summaries

In developing a set of procedures for determining the cost of various training options, several considerations were judged important. The first of these was a decision concerning what actually constitutes a training option. The second consideration involved the necessity of including both man-hours and dollar costs in determining the total cost of each training option. A third consideration was the necessity of evaluating each option in terms of both resident and on-the-job training. Finally, whatever costing techniques were generated had to include provisions for incorporating local cost variations. This is necessary since all training locations will not incur the same costs for similar training methods and media.

Once the costing guidelines were established, a decision was made to use cost rating techniques. This approach is based on the fact that actual dollar costs may vary over time but relative differences in costs will stay essentially constant. Using a cost rating technique will reduce the need for constantly updating the cost figures. Cost ratings can include not only dollar costs, but also student time information without the need for converting hours to dollar figures. The cost ratings can also include relative costs for various instructional methods by ranking each method on relevant costing dimensions. These considerations argued strongly for the development of costing procedures based on a cost rating scheme.

Defining a Training Option

Initially, the tasks selected to be taught in resident training and on-the-job training were identified as separate options. However, this approach later proved to be undesirable. It was originally reasoned that all tasks in an MOS constitute a single set. Once a portion of these tasks are identified as tasks to be taught in resident training, the remainder of the tasks automatically default to OJT mode. Therefore, a training option is defined as containing tasks to be taught in resident training and tasks to be taught in OJT.

Having arrived at this position, a second problem became apparent. A training option can be defiend as containing tasks taught in either resident or on-the-job courses as long as these are the only relevant training categories. If there are tasks which are not taught in either of these situations, then the definition is not complete. Based on past experience in specifying training programs, the project staff concluded that one additional training category needed to be included. The final category was "no training". Although it was anticipated that no tasks will be assigned initially to no training, later requirements, based on a lack of training time or excessive training costs, may necessitate assigning some tasks to the no training category. Therefore, the final definition of a trainin option included three task categories:

1. Tasks assigned to resident training
2. Tasks assigned to on-the-job training
3. Tasks given no formal training

A decision was made to address OJT costs first, since these costs have a large "hiddcn" factor associated with them. In general, the apparent factors involved in OJT are:

1. The number of hours available in a learning cycle
2. The number of hours required to learn the tasks

The first step was to define the learning cycle. Under current Army policy, there is a relationship between the amount of time that a trainee is allowed to learn all EPMS Level-1 tasks, and the time constraints governing promotion to E-4. A soldier is not required to demonstrate mastery of Level-1 tasks until just prior to promotion to E-5. Since the requisite promotion time is two years, and since there is no requirement to demonstrate mastery until that time, the basic learning cycle is considered to be two years. This calendar time was used as a baseline for computing individual real time (IRT) available for task learning.

As the factors causing the reduction of the two-year calendar time cycle were identified, it became apparent that the factors affecting year one do not affect year two. Consequently, it was decided that IRT had to be computed on a year by year basis. The factors affecting year one were identified as follows:

1. The percentage of calendar time in year one spent in Basic Combat Training (BCT), Advanced Individual Training (AIT), and in travel, leave, and processing status (TVLP) prior to arriving at the unit.
2. The percentage of calendar time consumed by standard non-productive time (SNP) factors. These factors are identified in Army Regulation 570-2 which provides guidelines for man-hour reductions considered for Tables of Organization and Equipment (TO&E) for Army units.
3. The percentage of time after SNP reductions consumed by unit movement and deployment. These figures are also found in AR 570-2.

4. The percentage of time that the system under consideration is committed to missions that prohibit its use for training.

Estimates for the above times were obtained from typical unit schedules.

The IRT for year two was found to be affected only by SNP, unit movement, and mission time. The items used for computing Individual Real Time are thus listed as follows:

1. Number of hours in a normal duty day
2. Number of duty days in a duty year
3. Hours spent in BCT, AIT, TVLP
4. Standard non-productive factors
5. Unit movement and deployment factors
6. Number of hours that equipment commitments permit training
7. Number of hours within which non-equipment tasks can be learned

The next step was to convert the calendar year to a duty year using the guidelines outlined in Army Regulation AR 570-2. The AR requires that the 365-day year be reduced by the ten legal holidays observed during the year, and the result multiplied by eight to establish a man-hours-per-year base. Weekends are not eliminated because a seven-day week is assumed. The individual real time (IRT) for both years is computed using the above time base.

To compute IRT for year one, the time base is first reduced by the number of hours that the trainees spend in BCT, AIT, and hours lost in TVLP. The time remaining after this operation is next reduced by the SNP factor in accordance with AR 570-2. The time remaining after these two subtractions is further reduced by the unit movement and deployment time (UMT) factor. UMT accounts for time lost in unit relocations. The result is the IRT for the first year of the cycle (IRT-1). Since the BCT, AIT, TVLP factors occur only in year one, the process for computing IRT for year two (IRT-2) does not include these reductions. In computing the IRT for year two, the base is reduced only by the SNP factor and the UMT factor.

When the computations for IRT-1 and IRT-2 are completed, the two values are summed giving the cycle individual real time (CIRT) available. At this point, the sum of the task learning times for the tasks assigned to OJT in the option are compared with the CIRT. If the sum of the task learning times is greater than CIRT, the option is specified as not time-viable due to the excess task hours assigned to OJT. If the option is time-viable at this point, a second test is specified. The time-viable options are checked to insure that task learning times assigned to both equipment and non-equipment related tasks do not exceed the time available. The procedures for these checks were developed by constructing a system commitment table as illustrated in Table 2-6. The illustrated table does not address any particular system and contains hypothetical data for a four-week period.

TABLE 2-6

Sample System Commitment Table

STATE	WK 1	WK 2	WK 3	WK 4	TOTAL
A	56 hrs no Task Trng				
B		Dailies 14 hrs (56-14) = 42 hrs net			
C			56 hrs Eqp Trng		
D				56 hrs job function maint assist	
Real Time	56	56	56	56	244
Task Trng	None				42 Non-Eqp. 56 Eqp.

Table 2-6 shows that there are 244 duty hours in a one-month period. Of these 244 hours, 56 will accommodate equipment-related task training, and 42 will accommodate non-equipment-related task training. The percentage of time that equipment task learning can be accomplished constitute approximately 23 percent of the time available. Assuming that Table 2-6 depicts a typical period that is repeated throughout the cycle, CIRT can be multiplied by the percentage of time available for each category yielding the maximum number of hours by task category that can be devoted to learning. The sum of the task learning times in the categories may not exceed the hours available. The system commitment table also must be constructed to conform to on-site conditions for the system under consideration. There is no default option for this information; a table must be constructed.

Resident Option Cost Indicator (ROCI)

The costs incurred in establishing and operating a resident training facility were identified as direct and indirect. Although these categories are adequate for actual dollar cost computations, they were judged not adaptable to the concept of cost differences based upon situational changes. The changes of concern are those associated with moving training method hours from resident to OJT, from OJT to resident by adding or deleting method hours, or exchanging one method for another. All of these options are judged to be potential means of reducing training costs.

The training methods are next placed into seven method cost classes which affect changes in cost variables. The method cost classes and the methods assigned to each are listed below.

Class	Method
1	Conventional Classroom, demonstr ation, case study, and guided discussion
2	Peer tutor
3	Tutoring
4	Programmed instruction (student and program paced), games, in-basket, and study assignment book
5	Traditional practical exercises
6	Programmed practical exercise
7	Computer assisted instruction

The direct and indirect cost variables are placed into seven classes. These vary as a result of training method changes. The cost variables used are:

1. Square footage
2. Instructor to student ratio
3. System equipment
4. Furnishings
5. Expendable supplies
6. Training aid development
7. Training material development

To determine the relative cost of each training method, the method cost classes are ranked on each of the cost variables as illustrated in the method cost class and square footage example shown below.

Method Cost Class	Sq Ft
1	1
2	3.5
3	3.5
4	3.5
5	6.5
6	6.5
7	3.5

The cost variables are assigned scale values ranging between one and seven on the basis of their judged relationships. For instance, the square footage factor for traditional classroom training is assigned a value of one because this method can accommodate more students per square foot than any of the other methods. The square footage factor for peer tutor, tutor, programmed instruction, and computer assisted instruction are each assigned a value of 3.5 because there is no apparent difference in the amount of room needed for their application. These four tied rankings occupy positions 2, 3, 4, and 5 on the one to seven scale. Similarly, the square footage variable for traditional practical exercises and programmed practical exercises are assigned a scale value of 6.5 because there is no judged difference in the amount of room needed to employ them. These two tied rankings occupy positions 6 and 7 on the rating scale.

The six remaining cost variables are also assigned scale values using the above procedure. The seven method cost classes and seven cost variables are then arranged in a table as illustrated in Table 2-7.

TABLE 2-7

Cost Ranking

Method Cost Class	SQ FT	INST/ STU	SYS EQ	FURN	EXPEN	TNG AID DEV	MAT	AVERAGE RANK	Y
1. Traditional Classroom	1	3	1.5	3	3.5	2	3	2.4	1.25
2. Peer Tutor	3.5	4.5	3.5	3	3.5	2	1.5	3.1	1.33
3. Tutor	3.5	7	3.5	3	3.5	2	1.5	3.4	1.40
4. Programmed Instruction	3.5	1.5	1.5	5	3.5	5.5	5	3.6	1.43
5. Traditional Practical Exercise	6.5	6	5.5	1	3.5	4	3.5	4.3	1.53
6. Programmed Practical Exercise	6.5	4.5	5.5	6	3.5	5.5	6	5.4	1.72
7. Computer Assisted Instruction	3.5	1.5	7	7	7	7	7	5.7	1.74

After all of the cost variables have been assigned scale values, a mean rank, $\bar{X}$, is computed for each method-cost class. For example, the computation of the mean rank for method-cost class one (traditional classroom) is:

$$\bar{X} = \frac{1 + 3 + 1.5 + 3 + 3.5 + 2 + 3}{7} = 2.4$$

After the mean ranks are computed, the conditions for determining the relationship between the cost intervals and the rank intervals are set. The lowest cost method is assigned a value of one, and the highest cost method a value of two. Since the number of intervals within a range of whole numbers is equal to the highest number in the range minus the lowest number in the range, the cost interval in Table 2-7 is 2 - 1 = 1; the rank interval for the seven-variable scale is 7 - 1 = 6. The relationship of the one cost interval to the six rank intervals is the ratio of 1:6 or .167. This ratio is used as a constant to compute the cost multiplier for the mean ranks of the method cost classes.

The mean rank cost multiplier, labelled "y" in Table 2-7, is derived by subtracting one from the mean rank, multiplying the difference by the cost ratio, and then adding one, (e.g., y = (rank - 1 (x)) + 1). The number of hours of each method within the training cost option is multiplied by its cost factor to get the method cost indicator (MCI) for the method. The MCI for all methods within the training option are then summed, yielding a resident option cost indicator (ROCI).

The cost factors in the initial example are computed using a hypothetical situation in which the range from the lowest to the highest cost method is doubled. Table 2-7 presents the cost data for this situation in column "y". New values for the cost multiplier must be developed if the cost situation changes.

<u>On-The-Job Option Cost Indicator (JOCI)</u>

The seven method cost classes and cost variables were examined to determine their applicability to on-the-job training. The computer-assisted instruction (CAI) cost class was judged to be non-applicable and eliminated. It was reasoned that most OJT environments will not have the hardware or software needed to employ CAI as a training method. The square footage cost variable was eliminated because of the fact that special facilities will likely not be constructed for initial on-the-job training.

The six remaining method cost classes and cost variables are next placed in a table, and used to compute the JOCI using the same procedures that are used to compute the ROCI. For both the ROCI and JOCI tables, entries of cost ranks for the methods must be changed when new data become available. The only portions of the table that are fixed are the number of method classes and the cost variables.

Training Option Cost Indicator (TOCI)

The resident option cost indicator (ROCI) and the on-the-job cost indicator (JOCI) are summed to obtain the training option cost indicator (TOCI). The TOCI can be used to compute a ratio reflecting the cost-effectiveness of one training option versus another. This ratio provides the training manager with an indication of relative training cost of two options. The cost-effectiveness ratio will indicate which training option or options are prime candidates for a more complete cost and training effectiveness analysis.

SECTION III

MODEL IMPLEMENTATION

Overview

The development of the TDDA was performed in two phases: a manual and a computer-aided mode. Although every effort was made to develop a conceptual or theoretical model separately from the applied model, this goal was not completely achieved. The major elements of the model (e.g., selection of training algorithm, selection of stimulus media, selection of response acceptance mechanism, etc.) were specified on the basis of the conceptual framework for developing training specifications. However, the variables used to operationally define the concepts were obtained from the environment. This was true for the task training prescriptions, the task hierarchies and priority ratings, and the cost indicators.

During the initial development process, each available variable was carefully considered before being included in the model. The variables were compared to one another to help insure their independence. They were also checked to insure their availability and reliability. No variables that would complicate the data collection process, or require data of questionable validity were included. One major problem that had to be avoided during model development concerned unnecessary complexity or sophistication. In previous efforts to develop processes for determining how, what, and where to conduct training, relatively sophisticated models were evolved. One example of these is the ISD process, which consists of five volumes of information and procedures (see TRADOC Pamphlet 350-30). This material is so complex that many course developers report difficulty in using the procedures. Some course developers avoid the ISD materials altogether. The development of the training developers decision aid (TDDA) constitutes a deliberate attempt to incorporate the principles of ISD in a simplified and systematic form. The extent to which this goal was achieved will be determined during the validation efforts planned for the second year of the project.

Manual Model

The manual TDDA model is developed around the flowcharts discussed earlier in the report. The process is simply that of having the training developer work through the model partitions in order (i.e., I, II, and III). The training developer first determines the training prescription for each task. This is done by identifying the training algorithm, the stimulus medium, the response acceptance mechanism, the training method, and the training setting. The training prescription is developed prior to identifying or selecting the tasks for training. This step makes the job of completing the training specifications for an entire MOS somewhat tedious. Tasks which will eventually be excluded from training are given training prescriptions. The action was judged to be warranted primarily because decisions concerning whether or not to include a particular task in resident training or in formal on-the-job training are based on the training prescription for that task. It was thus judged desirable that all tasks in an MOS have training prescriptions developed for them as a first step.

Once all of the tasks had been taken through Partition I, which generates training prescriptions, each task is next cycled through Partition II. In Partition II, priorities for inclusion in initial training are calculated. Additionally, the pay grade, system equipment, support equipment and task matrices are developed. The manual model is designed to permit the training developer to utilize whatever decision rules are currently standard. Tasks are selected for inclusion in resident training on the basis of these rules. The remainder of the tasks are assigned to on-the-job training by default. The manual model makes no attempt to take any decisions away from the training manager. The model merely organizes the data in a way that will facilitate the training manager's decision making process.

Once the initial list of resident and OJT tasks are developed, the model is designed to permit the application of the costing procedures to each training option. The training manager can develop more than one option before applying the costing procedures. A training option consists of a specification of tasks assigned to resident training, on-the-job training, and no formal training. The decision to include all three of these categories is based on the realization that there may be schools in the Army which have neither the resources nor the facilities to provide resident training and on-the-job training for all of the MOS courses that they teach.

After a training option is developed, the costing portion of the model is applied to the option. The model is developed so that the two or more steps which involve man-hour availability computations are performed first. This is done to determine the time-viability of the option before continuing the process. In this manner, training options that require on-the-job learning times in excess of the total time available are screened out. When the number of tasks assigned to OJT results in a required learning time that exceeds the time available for training, the training option is declared non-viable and additional choices must be made. The training manager may then place some of the tasks that are in OJT in resident training or in the no training category. The result is a time-viable learning situation for on-the-job training. Once the gross task learning time is within acceptable bounds for each of the options, the training developer then proceeds with the remainder of the costing effort. The costing elements generate a cost figure for both resident and on-the-job training. Cost elements for different training options can be compared to determine where the highest training costs will be incurred.

All aspects of the manual TDDA model are actually performed by the training developer. This approach was taken so that it would be possible to determine the time requirements imposed by the TDDA process. It is important to determine whether the model can be exercised in more, less, or the same amount of time as other procedures. The development of the manual model is also directed at assessing the quality of courses produced using the TDDA compared to those produced through some other vehicle.

Computer-Aided Model

A second version of the training developer decision aid was developed for use in a computer-aided environment. In this mode, a computer program performs many of the activities involved in the manual mode. Given a question set composed of questions requiring "yes/no" answers, the computer-aided model provides the training developer with the same output as the manual process. The requirements imposed on the training developer for operating a computer-aided environment are as follows. First, the developer completes an MOS task data sheet for each task. Next, a task data base is constructed. Partition I, the portion of the model that generates the training prescription for each task, is automatically completed for all of the tasks. Finally, the training developer is provided with a printout of the training prescription for each task. At this point, the training developer can review each of the training prescriptions on the basis of his answers to the task data sheet, and determine whether or not the prescriptions are acceptable. Depending upon whether or not the training prescriptions are judged to be acceptable, two courses of action can be taken. A new set of responses to the training prescription questions can be entered, or the training developer can proceed by requesting the machine to generate the task hierarchy and course sequence information.

Partition II of the computer-aided model provides the TD with a printout containing information on system equipment, support equipment, tasks for each pay grade, the training priority of each task, and the hierarchy of tasks implied by the reported skill dependencies. The training developer can then either modify this output by changing his responses to Partition II questions, or accept the results and specify which tasks are to be placed in resident and which are to be placed in OJT training. The training developer can generate a maximum of three training options. Once the options are specified, the training developer can request Partition III to cost the options. The computer-aided model will indicate the time-viability and the cost of each training option. As with the manual TDDA model, validation work on the computer-aided model will be initiated in the second year of the project.

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