

The Design of Instructional Systems

by

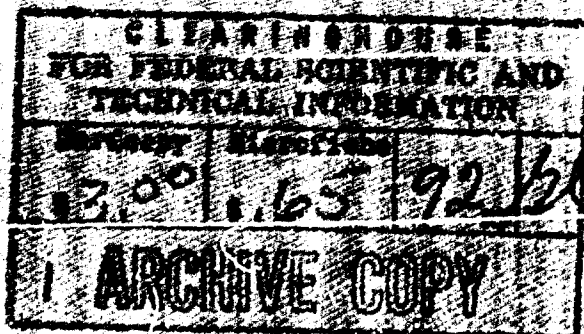
Robert G. Smith, Jr.

November 1966

Prepared for

Office, Chief of
Research and Development
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CRD/J

SUBJECT: The Design of Instructional Systems

TO:

CHIEF OF RESEARCH
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1. This report was prepared to provide general guidelines for a system approach to the design of training programs, in order to develop programs that will be maximally effective and yet operate at minimum cost.
2. The report is based on an extensive literature survey and upon training research which has been conducted by the Human Resources Research Office. Instructional system components which are discussed include presentation of information, practice techniques, student management, quality control, evaluation of the system, and cost effectiveness.
3. This report, one of a series dealing with the technology of training, will be of interest to agencies or personnel concerned with the design and evaluation of instructional systems.

FOR THE CHIEF OF RESEARCH AND DEVELOPMENT:

A handwritten signature in black ink, reading "Robert B. Bennett", is written over the typed name.

ROBERT B. BENNETT

Colonel, GS

Acting Chief, Human Factors and
Operations Research Division

The Design of Instructional Systems

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HUMAN RESOURCES RESEARCH OFFICE
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Technical Report 66-18

FOREWORD

This report presents a general account of one facet of the technology for developing effective training, that of designing instructional systems. The material is based on a survey of available literature, and drawn particularly from Human Resources Research Office experience and methodology in training research.

While it is expected that many of the ideas and techniques reported will be superseded as research and development for training advances, the treatment of present technology concerning instructional system design was prepared to provide guidelines to military personnel currently involved with military training programs.

This report is part of a series of closely related HumRRO publications by Robert G. Smith, Jr. dealing with various aspects of the technology of developing training. The series includes The Development of Training Objectives, Research Bulletin 11, June 1964; and Controlling the Quality of Training, Technical Report 65-6, June 1965. Each of the technology reports is supplemented by an annotated bibliography, which provides more detail on the literature available to the instructional system designer. They are: An Annotated Bibliography on the Determination of Training Objectives, Research Memorandum, June 1964; An Annotated Bibliography on Proficiency Measurement for Training Quality Control, Research Memorandum, June 1964; and An Annotated Bibliography on the Design of Instructional Systems, Technical Report in preparation.

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Meredith P. Crawford
Director
Human Resources Research Office

Problem

A training program set up to accomplish a number of specific objectives is composed of many elements. These include lectures, demonstrations, films and other types of training aids and devices, practical exercises, techniques for controlling student activity during training, and tests for quality control. For the training program to be maximally effective, all these elements must be integrated into a system, designed to accomplish the objectives at minimum cost. Various principles and techniques of learning must be applied in the development of the system.

This report is one of the Human Resources Research Office publications on aspects of the technology for developing training. It summarizes the state of the art at the time of writing, and is designed to provide general guidelines for the design of instructional systems.

Background

To be certain the desired objectives are attained in an efficient manner, an instructional system should be built around these essential functions:

- (1) Development of training objectives based on the job for which the student is being trained.
- (2) Practice of task performance until the student has attained the objective.
- (3) Practice of the knowledges and skills that are components of the task.
- (4) Presentation of knowledge to the student.
- (5) Control of student activity to maximally direct it to learning.
- (6) Control of the training quality by means of a system developed for this specific purpose.

Approach

The presentation is based on a survey of the available literature and draws particularly on HumRRO experience in research studies on training. To provide relevant references for a particular topic, specific references are cited for each chapter in the Selected Bibliography and are supplemented with additional uncited references pertinent to the topic.

The major sections of the report deal with (a) the instructional system as a concept, (b) the research evidence bearing on the major system functions, and (c) methods for designing and evaluating the system in terms of cost and effectiveness.

Findings and Conclusions

Selected findings and conclusions are listed below. While these general guidelines will, in some instances, need to be supplemented by specific procedures devised to meet particular training situations, they should serve to indicate some of the considerations involved.

- (1) The principal concept is that of the instructional system as an integrated set of media, equipment, methods, and personnel, all performing efficiently the functions required to accomplish one or more training objectives.
- (2) The critical aspects of practice of performance are:
 - (a) To simulate the job task, using a detailed task description as a guide.
 - (b) To provide for knowledge of results.

- (c) To arrange a suitable practice schedule.
- (d) To maximize transfer of training.
- (3) The critical aspects of practice of *knowledge* are:
 - (a) To determine, through analysis, the relation between the cues and responses required by the knowledge.
 - (b) To develop, through practice with knowledge of results, a high level of achievement.
 - (c) To devise ways of making material meaningful to the trainee.
- (4) Presentation of knowledge can be done successfully by any of several methods, provided:
 - (a) The presentation communicates to the student.
 - (b) The material presented is meaningful.
 - (c) The special characteristics of the various media are taken into account.
- (5) The management of students is concerned with:
 - (a) Arrangements for dealing effectively with individual differences.
 - (b) Reinforcement of the learning of tasks.
 - (c) Overall sequencing of tasks to be learned.
 - (d) Controlling avoidable absences from classes.
- (6) Automated instruction makes possible the consistent teaching of large numbers of students. It can be especially useful where instructor shortages exist or when training must be decentralized. It has the drawback of not being easily modifiable in the light of changing training requirements.
- (7) Instructional devices and media should be selected in terms of cost and effectiveness.
- (8) The entire system should be evaluated in terms of cost and effectiveness.

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The Design of Instructional Systems

INTRODUCTION

A course of instruction may involve any of a number of aids and activities: lectures; formal and informal tests; training films and other training aids, devices, and simulators; practical exercises; procedures for maintaining classroom discipline; counseling procedures; programmed instruction. How can these be used effectively, and for what kinds of instruction are they suitable? How can they be combined into a coordinated, integrated system, so that each instrument or technique reinforces the others? How can one determine the relative merits of different aids and techniques for a given purpose? These and other questions with which the course designer will be concerned as he develops a training program are dealt with in this report.

The key concept, discussed in detail in Part I, is that of an instructional system as a coordinated set of instructional aids and activities designed to be as efficient as possible. The nature of an instructional system, cost-effectiveness ratios, automated instruction, and computer-based instruction are some of the topics considered. Part I is concerned, too, with the general functions that must be considered and designed into an instructional system. The advantages and disadvantages of various ways to accomplish the goals of the system are described.

The unifying concept throughout much of Part I is that of transfer of training—how to arrange a series of training activities so that one learning experience transfers positively to others.

Specific problems concerning the design and evaluation of the system are taken up in Part II. These include sequencing instruction, designing lessons, and managing students.

References which provide much of the basis for this report are cited separately for each chapter, in order to provide the reader with information on available literature pertaining to a topic in which he has special interest. Additional references relevant to the general chapter topics are also supplied.

This report is the third in a series of reports on training technology by the present author. The other reports concern training objectives (1) and quality control for training programs (2).

Part I
INSTRUCTIONAL SYSTEMS—CONCEPTS
AND FUNCTIONS

Chapter 1

WHAT AN INSTRUCTIONAL SYSTEM IS

For the purposes of this report, an instructional system is defined as an integrated set of media, equipment, methods, and personnel performing efficiently the functions required to accomplish one or more training objectives. These objectives are statements of the performances required of the student after training.

Modern training concepts emphasize the importance of planning training programs with a clear specification of objectives derived from careful analysis of the job the student will perform after graduation (Smith, 1). The instructional system components required to reach a given objective must be carefully selected and assembled. Both the effectiveness of the components and the cost at which a given level of effectiveness can be attained must be considered and measured.

A MODEL OF AN INSTRUCTIONAL SYSTEM

A general model of an instructional system is presented in Figure 1. The system is composed of a student and the following functions: Practice of Performance, Practice of Knowledge, Presentation of Knowledge, Management of Students, and Quality Control. Training objectives based on the job the student will perform are an integral part of the system. Figure 1 also shows how the

A Model of an Instructional System.

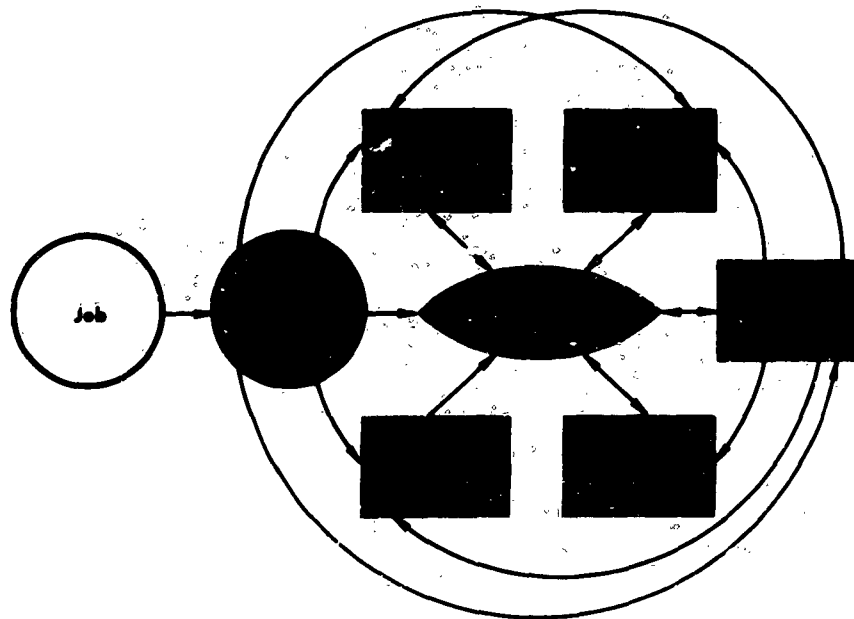


Figure 1

functions work together to accomplish the objectives necessary for performing the job. The salient features of each part of the model are discussed in this section. More detailed research findings concerning the design of each of the functions are described in later chapters.

The Practice of Performance

The objectives of training specify the tasks to be learned, as well as the skill and knowledge components that contribute to task performance. By the practice of performance is meant the practice of the task and its skill components.

In developing the training objectives, detailed descriptions of each task should be prepared (Smith, 1). These descriptions form the basis for the design of situations in which the student practices the task until he has learned it.

To a certain extent, any practice exercise is a simulation of the job. In some situations, actual equipment and material required on the job will be used in the practice exercise. In other situations, obsolete equipment or training devices may be used. Guidance as to what should be simulated will be found in the cues, actions, and indicators of correct action listed in the detailed task description.

Training devices, widely used in training, can be extremely useful. Many devices, however, are more expensive or less effective than they should be. Excessive "realism," or the simulation of more of the actual equipment than is required for the task, can be very costly. However, leaving out relevant aspects of the task can reduce effectiveness.

One distinction that has been made with regard to training devices is that between "whole task" and "part task" devices. The "whole task" device, which provides practice on one or more complete tasks, is frequently very expensive. Under some circumstances "part task" devices, which provide practice on only a key portion of the task or set of tasks practiced on the "whole task" trainer, can provide effective training at a much lower cost.

Certain tasks may be taught using obsolete, rather than the newest, equipment. This practice, where appropriate, may reduce costs. Again, the detailed task description is the guide.

Practice exercises and training devices should be designed in such a way that appropriate forms of knowledge of results can be provided the students. The nature of the knowledge of results must be suited to the student's needs or it will be ineffective.¹

Properly designed practice exercises provide transfer of training to the job. That is, what is learned in the practice situation is transferred to a new situation—the job—so that learning time in the job situation is reduced. In situations in which a task must eventually be practiced on the actual equipment or on a complex simulator, the use of simpler devices may provide transfer to the complex simulator and thus reduce the requirements for supplies of the more expensive equipment. In this way the overall cost of effective training may be reduced.

The Practice of Knowledge

The learning of every task presupposes the learning of some, even if only a few, knowledge components. Knowledge refers to symbolic processes. The practice of knowledge means that the student gives symbolic responses and receives information as to their correctness.

¹Knowledge of results is discussed in detail in Chapter 2.

The knowledge components are required for effective task performance, and mastering them will transfer to the practice of performance. The equipment and material for the practice of knowledge are frequently less expensive than those for practicing performance, and it is efficient to take advantage of this. At the same time, research results show that little transfer takes place unless the knowledge is mastered by the student.

The guide for the particular knowledges that should be practiced for each task or set of tasks is the hierarchical organization of the knowledge components of that task. To design effective procedures for practice, special analyses of these knowledge components must be made.

Presentation of Knowledge

Much, if not most, training activity involves the presentation of knowledge to the student, often with little else provided. Presentation can employ a variety of techniques--lectures, reading, graphic aids, films, television, and tape recorders, for example. A great deal of knowledge can be presented in a short time. A single presentation can be received by many students at the same time. Presentation is less expensive than practice.

These seeming advantages are often illusory. Students frequently fail to pay attention. Presentations are often made at such an abstract level, or with such speed, that the student fails to grasp the content. Or the level of presentation may be too elementary, and the student becomes bored.

In a group of students, the majority will learn something from a well-organized, properly paced presentation geared to the level of the student. However, the research evidence is quite clear that students learn more when presentation is integrated with practice. Since presentation is a one-way street, there is no way for the training system to determine the effectiveness of presentation until the practice stage has been reached.

Management of Students

The function of management of students refers to those features of the system that keep the student productively participating in the learning activity. These include:

- (1) Short-term incentives to insure motivation
- (2) Arrangements for dealing with individual differences
- (3) Procedures for minimizing absences from class

In the design of the student management function, incentives contingent on successful progress in training can be provided, although this is frequently not done. It is also possible to avoid the kinds of practices that would amount to rewarding students for failure.

A number of possibilities exist for dealing with differences in student ability. All of these have in common some form of individualized treatment of the student. These methods create administrative problems for most Army training programs, which, on paper at least, are generally the same length for every student. One way of adapting to individual differences is by recycling, to create courses that are really of variable length.

A set of procedures should be established to monitor student progress and--depending on the progress or lack of it--provide the basis for making various decisions concerning the student.

Quality Control

The purposes of a quality control system are described in detail in an earlier report (Smith, 2). Generally, such a system is a set of procedures involving the development and use of tests of the objectives. The tests are administered to the students, and the results are used as a basis for continuing improvement of the instruction.

Quality control has a very important function in the development of an instructional system. This is to obtain data on the effectiveness of the system in accomplishing its objectives and to provide guidance as to how to change the instructional system to increase its effectiveness.

INSTRUCTIONAL SYSTEM DESIGN

The major steps in the design of the instructional system are:

(1) Preparing the training objectives

The training objectives define the purposes of the instructional system. They should include not only a statement of the tasks to be performed on a job at the end of training, but also the component knowledges and skills required for task performance. A properly prepared set of objectives will provide overall guidance to the system designer, which will aid in the integration of the various parts of the system.

(2) Sequencing the objectives of the system

The objectives of the instructional system cannot be achieved all at once; they must be sequenced.¹ Proper sequencing of training activities is vital to the effectiveness of the system. Some forms of sequencing make the objectives interesting and easy to master; others make them boring and difficult to master.

(3) Identifying required functions

The model of an instructional system (Figure 1) suggests the functions required by the system. For any particular objective, the relative emphasis on any particular function may differ from that of another objective.

(4) Selecting components and procedures

After deciding generally on the relative emphasis to be given each function for any particular objective, system components and procedures are selected to accomplish the objective. How is the task to be practiced? Using actual equipment, training devices (what kinds?), obsolete equipment, or what? What kinds of materials must be prepared to provide practice of knowledge? What methods for the presentation of knowledge will be used—books, lectures, films, television?

(5) Analyzing cost-effectiveness

A cost-effectiveness analysis should be made of the system possibilities. If several components and procedures seem equally effective, their relative costs should serve as a guide to their selection. Analysis of costs and effectiveness is a continuing process throughout the development and operation of the system.

(6) Coordinating components and procedures

The entire instructional system should be examined to determine whether it will be a smoothly working, integrated whole. This examination should be continuous, during both the later stages of system development and the actual system operation. Flow charts and computer simulation are

¹Guidance for sequencing is presented in later chapters of this report.

valuable tools for this type of study; observation of the operation of the system is indispensable.

(7) Evaluating the system

The need for cost-effectiveness concepts in selecting system components has been mentioned. It is also desirable to evaluate the complete system in terms of cost and effectiveness. The index of effectiveness is the number of attainable objectives actually attained by the students. This information will come from the quality control system. The total cost must be developed from data on the variety of costs that make up the total.

System evaluation is a continuous process. Systems are not static; they develop and change. The impact of external pressures may degrade the system. Improvements of different kinds will be made. It is desirable to know the impact of these pressures, and the effect of improvements on the cost-effectiveness ratio.

Chapter 2

THE PRACTICE OF PERFORMANCE

The culmination of any training sequence is student practice of the performance required by the training objective. As used in this chapter, the term performance refers to both the task level objective and the skill (not knowledge) components of the task.

Factors that contribute to the effectiveness with which performance is practiced, as well as those that can reduce the cost of practice, are described in this chapter. Also, general guidance is provided to assist the instructional system designer in designing effective practice situations at minimum cost. This guidance leaves ample room for the exercise of creative ingenuity on the part of the system designer.

PRACTICE OF THE TASK

A task is a meaningful unit of job performance. It is a group of activities that generally occur close together and have a common purpose.

It is essential that the student, when he practices performance, practice the task for which he is being trained. And he should practice the whole task, not just a part of it. As part of the process of developing training objectives, preparation of a detailed task description—a complete statement of the cues, actions, and indicators of correct action to be found in the task—is recommended (1). The best insurance that the whole task will be learned is to develop a practice situation based on this detailed task description.

The practice situation should, then, provide the cues to which the trainee should respond and controls or other equipment on which he should act; it should also provide him with indications as to whether his action was correct. The sequence of actions should be indicated in the task description; the student should practice this sequence, and no other—unless, of course, alternate procedures are stated in the task description.

Thus, the practice situation represents a simulation of the essential elements of the job task—cues, actions, and indications of correct action. From the standpoint of costs, it is generally expensive and unnecessary to simulate additional features of the job situation.

KNOWLEDGE OF RESULTS (KOR)

Forms of KOR

Knowledge of results (KOR) can take many forms. It can arise naturally out of the task environment. It can come from another person, such as a student or instructor. Special signals, such as lights or buzzers, may be used. Test scores may be reported to the student. The purpose of providing KOR is to inform the student whether his action was correct, or, in the case of continuous tasks, whether his level of accuracy is satisfactory. Certain types of KOR are particularly significant.

Natural KOR. Natural KOR arises out of the task environment. In the detailed task description it is the indication of correct action. In some instances, it is the evidence of the student's own senses. In other instances, the task is so unfamiliar that the student must learn the indications of correct action that represent KOR, if they are present. Once he has learned these indications, however, they are clear signals to him. In still other situations, the indications that form KOR are unclear even after considerable training.

The clarity of the natural KOR is an important consideration, because it interacts with the effectiveness of artificial KOR.

Artificial KOR. Artificial KOR does not arise out of the task itself, but is provided by additional means, such as instructor critiques of student performance, and mechanical aids such as buzzers, lights, or clicks.

Artificial KOR should be employed with reservations, as it may itself affect performance. If it is provided during practice of the task, it may raise the level of performance during practice; however, since the KOR is not natural to the task, performance may drop when the student goes to the job and the artificial KOR is no longer present. A number of tracking experiments have shown that the artificial KOR raises the level of performance, but that performance drops when it is withdrawn (Bilodeau, 3; Bilodeau, Bilodeau, and Schumsky, 4; Goldstein and Rittenhouse, 5). This finding is not a universal one, however. Other studies have shown no reduction in performance when artificial KOR was withdrawn. Kinkade (6) found that artificial KOR favorably affected learning on a permanent basis when there was clearly perceived natural KOR, even after the artificial KOR was withdrawn. On the other hand, when natural KOR was not clearly perceived, performance level was reduced when artificial KOR was withdrawn.

A number of experiments indicate that artificial KOR may be added when natural KOR is clearly perceived by the student, but should not be added when natural KOR is unclear.

Performance KOR vs Learning KOR. Miller (7) draws a useful distinction between performance feedback and learning feedback (feedback is a commonly used alternative term for KOR).

Performance feedback, or KOR, is the environmental information that tells us to change our next response so as to perform the task better. Suppose we want to drive quickly from home to the office. We don't want to risk getting a ticket for speeding, so we look from time to time at our speedometer. If we are too far under the speed limit, we push down on the accelerator; if we are above the speed limit, we let up on the accelerator. This is performance KOR, because it permits us to change our responses to perform an ongoing task more effectively.

Learning KOR is given after a response has been made, and provides a basis for a more correct response to the same cue conditions when they next occur. It is as if the individual said to himself, "I now see what I should have done."

The significance of the distinction between learning KOR and performance KOR is this: Instances showing poor performance after the withdrawal of artificial KOR have been examples of artificial performance KOR, rather than artificial learning KOR.

Generalizations Concerning KOR

Ammons (8) reviewed the literature and developed a number of generalizations and possible applications of KOR. Some will be presented here, as a guide

to making effective use of KOR. These generalizations should not be accepted uncritically, however; they may require checking in particular settings.

(1) The performer usually has hypotheses (or guesses) about what he should do and how he should do it. These interact with KOR. The guesses the student makes about the practice situation may make him pay attention to the wrong cues. Or they may lead to incorrect responses. The student may use incorrect or irrelevant information as KOR. It is therefore important to correct wrong guesses as soon as possible.

(2) Some KOR is nearly always available to the human performer. The learner uses what information is available to him, from the environment or from his own memory. In a number of studies cited by Ammons, groups not receiving KOR that was designed by the experimenter learned as well as those receiving KOR in a formally designed way. The groups not receiving formal KOR were getting their own KOR from the environment. However, training inefficiency occurs when the KOR obtained from the environment is irrelevant or wrong.

(3) KOR increases the rate of learning and the level of performance reached by learning. In the great majority of instances, an experimental group that has received KOR learns more quickly and reaches a higher level of performance than one that has not.

(4) KOR affects motivation. There is a tendency for KOR to make learning more interesting to the student. However, he may be interested simply in scoring higher, and he may cheat or take advantage of weaknesses in the situation to make a high score. It is important that practice situations be designed to control this possibility.

(5) The more specific the KOR, the faster the improvement, and the higher the performance level. Other things being equal, the more specific the information as to how the student has performed, the more likely he will be to correct erroneous responses. This statement should be qualified, however. In the early stages of practice on a complex task, too much specific information may be confusing. In fact, one of the things a student has to learn is how to make use of a wider range of information.

(6) The longer the delay in providing KOR to the student, the smaller effect it has. Most studies show that delays of as much as a few seconds after the response can make KOR less effective. A study by Bilodeau and Bilodeau (9) shows that if there is no activity required of the student between the response and KOR, delay of KOR has no effect. However, in the majority of learning situations further activity will be required.

In most practical learning situations, this principle of providing KOR rapidly is violated. Tests are scored but the results are not given to the student for several days, for example.

(7) When KOR is decreased, performance level tends to drop. While provision of artificial KOR may raise the level of performance during practice, performance tends to drop when the artificial KOR is withdrawn if there is no clearly perceived natural KOR.

Suggestions for Application of KOR

Most of the following suggestions for applying what is known about KOR are taken from Ammons' (8) review, with modifications:

(1) Develop methods for correcting or eliminating student hypotheses or guesses that conflict with KOR. Ignorance on the part of students as to what must be learned can lead to rumors and interfering hypotheses about what is to

be learned. One way of correcting this situation is to provide students with a set of training objectives. Another is to provide an accurate description of the practice situation, and any training devices used in it.

(2) The design of all training and operational equipment should provide for KOR. If KOR is designed into operational equipment it becomes natural KOR, and can be used in the practice situation without any concern over its withdrawal in the actual job.

Care should be taken that natural KOR can be clearly perceived by the student if artificial KOR is to be used.

Consideration should also be given to planning the amount and specificity of KOR to be given at different stages of practice. Early in practice of a complex task, too much detail can be confusing. As practice proceeds, however, the student should be able to use more complex information.

(3) An appropriate lag in KOR should be provided for in the design of training and operational equipment. It is important that learning KOR follow practice performance of the task by an appropriate, but short interval. The optimum interval for a given task must often be found by experimentation.

(4) If it is impossible to provide KOR all the time, give it as often as possible. A further qualification on this statement is to avoid long sequences without KOR. Instead, in a sequence including practice trials with KOR, practice trials without KOR should be interspersed randomly.

(5) If a delay in KOR must occur, the student should wait quietly until KOR is received. Previously, evidence was cited showing that a delay in KOR did not reduce performance as long as there was no formal requirement for student activity between response and KOR.

(6) Where KOR must show the direction of the actual student response in relation to the correct response, include specific details. If the student responds by overshooting or undershooting, or aiming too far to the left or right, it is an example of a situation in which the direction of the response should be shown to students in the KOR. The inclusion of a directional component will be more effective than simply telling the student he was off-target or on-target. However, the student shouldn't be overloaded with too much complex detail in early stages of practice. It might be best to just indicate to him that he was, for example, overshooting or too far to the left. Then, as the training progresses, increasingly specific details concerning direction and distance may be included in KOR.

TRANSFER OF TRAINING

A student studies a photograph of a piece of equipment. He learns the appearance and location of each significant part of the equipment. Later, he mentally practices the steps of the procedure, referring to the photograph. Then he practices the procedure on the actual equipment. Because of his preliminary work on the photograph, he is able to learn on the actual equipment much faster than if he had not engaged in the earlier practice. What he learned in the earlier work has transferred to learning on the actual equipment.

By transfer of training is meant that what a student learns in one situation affects the ease of learning in another situation. This effect may be positive or negative. Proper management of training activities to enhance positive transfer contributes significantly to the effectiveness and economy of training. Positive transfer, for instance, is the basis for the design and use of training devices.

Identification of Transferable Content

Identification of task component knowledges and skills and synthesis of the components into an organized structure are part of the process of developing training objectives (1). These steps are prerequisites to identification of specific knowledges and skills that will transfer to the performance of the total task.

The organization of the component skills and knowledges will serve as a guide to the sequencing of content to encourage positive transfer. For instance, by mastering the lower level components of the task, practice on the total task may be reduced. There are a few exceptions, which will be treated in later sections of this chapter. In the following sections, research findings that offer guidance in planning for positive transfer will be described, as well as some precautions that suggest limitations on the concept of transfer.

Transfer of training has major implications for the cost of training. As will be shown in the later discussions of training devices and the practice of knowledge, students can practice on inexpensive devices; this practice will then transfer to more expensive practice situations. The inexpensive situation may be either a complete or a partial substitute for the more expensive situation.

Component Practice and Transfer

In general, if a task has been correctly analyzed into its component knowledges and skills, practice on a component will transfer to the task. The situation with regard to knowledge will be discussed in the next chapter.

Several studies (Bilodeau, 10; North and Harrington, 11; Seymour, 12) have shown that component skills can be practiced separately from the total task with considerable transfer. However, there are two exceptions that must be considered when planning to use component practice.

The first exception is time-sharing. A continuous task, such as flying an airplane or driving a vehicle, often must be performed during the same time period as a procedural task. Arrangements must be made to practice these together if satisfactory proficiency is to be attained (Adams and Hufford, 13; Briggs and Naylor, 14; Dougherty, Houston, and Nicklas, 15).

The second exception occurs when there is interaction between the task components (Briggs and Waters, 16). For example, in making a turn in an aircraft, the turn controls are operated, but at the same time the aircraft must be banked to an appropriate degree. If turning and banking are practiced as separate components, there will be little transfer to the whole task, which involves both banking and turning.

In summary, if the total task involves either time-sharing of activities or interaction of skill components, do not expect much transfer from component practice to the practice of the entire task.

EFFECTIVE PRACTICE

A number of factors that contribute to effective or efficient practice are described in this section.

Distribution of Practice and Rest

Distribution of practice and rest periods affects the performance being practiced. If the schedules for rest and practice are such that they depress performance, then we may be extending practice far beyond the amount really necessary to develop an appropriate degree of proficiency.

A trial is defined as a continuous practice session, whether the task is practiced once or several times (in the case of short tasks). Typically, a trial will be followed by a short rest.

It is difficult to generalize from the studies that have been performed to an optimum practice schedule; however, the following suggestions should help to prevent serious procedural errors.

When trials are short—on the order of a few minutes or less—then a rest of 30 to 45 seconds should be allowed between trials, followed by a ten-minute break after every ten trials. If trials are longer, then a rest period of 35 to 45 seconds should be allowed between trials, followed by a ten-minute break after every few trials.

If performance on the task is being measured to determine when a student has attained satisfactory proficiency, it is suggested that measurements be taken immediately after the ten-minute break.

If the student is given little or no rest, his performance level will be lowered. This will mean he will have to practice much longer than necessary to meet the appropriate standard of proficiency. On the other hand, if rest periods are excessively long, time will be wasted.

It is assumed here that the task makes minimal demands on the student's physical strength and endurance. If practicing the task develops significant amounts of fatigue, then longer rest periods must be provided.

Studies relevant to this section are those of Adams and Reynolds (17), Norris (18), and Reynolds and Bilodeau (19).

Verbalization During Practice

In the practice of procedures and problem-solving tasks, it has been found advantageous to require the student to talk his way through the task while practicing (Esper and Lovaas, 20; Gagné and Smith, 21; Newman, 22; and Ray, 23). This is one of the features of the LOCKON method of instruction (Woolman, 24), developed by HumRRO for the training of Nike missile operators.

Pacing

Some tasks are externally paced. That is, the actions must be performed within time limits established by a sequence of cues that are also timed. If the task is externally paced, practice should also be externally paced. The research evidence shows some trend toward an advantage for groups practicing on externally paced tasks when they switch to self-paced conditions (Adams, 25; Anderson, Kresse, and Grant, 26; Nystrom, Morin, and Grant, 27 and 28).

Overlearning

It is generally desirable, especially if retention of a skill is particularly important, for the student to overlearn. Overlearning, in the sense used here, can be defined as additional practice after performance standards have been met by the student. Important tasks should be overlearned, especially if there is little expectation of frequent review after initial learning. Overlearning, in addition to aiding retention, tends to prevent skill from deteriorating under stressful conditions, such as combat or other emergencies.

Mental Practice

Mental practice involves the individual thinking his way through the task, and perhaps making appropriate motions even though the normal job cues are

not present. Shadow-boxing is an example of such practice. If practice is required when actual equipment or training devices are not available, mental practice might be considered. In one situation, the practice of the one-hand basketball foul shot (Clark, 29), it was nearly as effective as physical practice.

Preparation for Practice

A situation frequently arises in practical exercises that may be a major contributor to inefficiency. This is the requirement for the student to spend considerable time preparing his materials before he can practice. Breadboards of electrical components may have to be assembled before the student can practice; laboratory equipment may have to be set up; equipment may have to be checked out of supply.

This preparatory activity is frequently wasted time, and it should be reduced to an absolute minimum. If equipment cannot be set up in advance, then the trainee should have clear instructions so that he can prepare the materials in as little time as possible.

TRAINING DEVICES

Some of the more important concepts relating to training devices are briefly described in this section. The interested reader is referred to Adams (30), Gagné (31), Miller (7, 32), and Lumsdaine (33, 34).

Why Training Devices?

Every practice situation is in some sense a simulation of the job. It was pointed out earlier in this chapter that the task must be practiced as defined by the cues, actions, and indications of correct action found in the detailed task description. Practice of the task must provide (a) simulation of the environment to provide the necessary cues, as inexpensively as possible, (b) an appropriate control or tool upon which the student can act, and (c) natural KOR.

In many circumstances these features can be provided using actual equipment in a realistic job environment. In other circumstances, such as the following, it is better to use training devices:

(1) The training device is frequently less expensive than the actual equipment, while still simulating the essential elements of the task. Also, the actual equipment may require the use of fuel or additional personnel not needed with the device.

(2) The training device may be the only feasible way to practice a task, as when there is a possibility of damage to equipment, injury to students, or destruction of property in performing the task.

(3) Training devices may be more reliable for practice purposes than the actual equipment. For instance, an operator's console in a missile system is connected to other parts of the system, and when the other parts are out of action, the operator's console may be affected. Through simulation, many such problems can be eliminated.

Cost-Effectiveness of Training Devices

A training device is one element in the practice situation. It is rarely the entire practice situation. The device should simulate the task to be performed,

including the cues, actions, and natural KOR of the task. All of the factors that govern effective practice should be built into the device, or, if this is impractical, into accompanying lesson plans.

Complete simulation of the actual equipment is seldom required, especially if the actual equipment contains parts not germane to the task. Numerous research studies indicate that unnecessary fidelity to the actual equipment may introduce material not relevant to the particular task being practiced, and therefore reduce training value of the device. A study that illustrates this point is that of Denenberg (35), which compared the effectiveness of a tank hull trainer, costing \$10,000, and a mock-up whose materials cost \$27. The mock-up was superior to the trainer for teaching starting and stopping procedures; in fact, trainees taught by the mock-up started and stopped the M47 tank nearly as well as trainees who had previous experience starting and stopping a tank. The mock-up, trainer, and tank were equally effective in teaching the nomenclature and location of the driver's instruments and controls.

A modern view of the training device considers it as an element in a training system. The desired characteristics and proposed method of using a device should therefore be considered during the development of training. When a training device will be extremely costly, the specifications for procurement of the devices should call for development and test of a training system for attaining the appropriate objectives.

Procedural Trainers

A trainer designed solely for the practice of a procedure—a step-by-step series of activities involving no special skill requirements—can be a very rough approximation of the actual equipment. Photographs or drawings, mounted on board, of about the same size as the actual equipment, will serve inexpensively to teach many procedures involving consoles and other equipment in which all cues and actions are in plain view. If feasible, KOR can be given by an instructor, or by another student who follows a description of the procedure. A few trials on the actual equipment or a more realistic trainer may serve to prepare the student for proficiency measurement (Cox, *et al.*, 36).

Skill and Continuous Task Trainers

Continuous tasks usually require complex displays and accurate control display relationships. Continuous task trainers tend to be more complex and more expensive than procedural trainers. Aircraft simulators and driver trainers, and radar tracking simulators are types of continuous task trainers.

Many of these simulators permit the practice of all tasks involved in the job. Time on the simulator may be reduced—and hence fewer complex simulators will be required—if certain procedural tasks can be practiced on simpler devices.

Obsolete Equipment

New equipment for training is frequently in short supply. Sometimes, however, a task can be practiced on obsolete equipment. HumRRO Work Unit FORECAST showed how a judicious combination of medium fidelity mock-ups representing new equipment, plus the use of obsolete equipment to practice tasks common to both old and new equipment, can reduce the amount of practice required on new equipment (Shriver, Fink, and Trexler, 37).

Whole Task vs Task Component Trainers

Trainers for a component of a task can often be less expensive than a trainer designed to permit practice on the entire task. Whether to use part task trainers depends on whether transfer from the component to the task will be expected. Earlier in this chapter it was pointed out that such transfer can generally be expected, unless there is time-sharing or interaction between the components.

THE ROLE OF THE INSTRUCTOR

The human instructor can perform several functions with regard to the practice of performance. He may instruct the student as to how to practice; he may monitor the class to determine whether instructions are being followed; and he may provide KOR.

As a giver of instructions he may be replaced—or his work supplemented—by written materials, tape recordings, films, and television. The choice among these would depend on the relative cost of each, since they are generally equally effective.

As a monitor, he can determine fairly easily whether students are working at the task being practiced, provided he is not required to supervise too many students at one time. When the instructor is performing as a monitor he is a part of the management of students function.

If the instructor must provide KOR in addition to monitoring, even a few students will constitute a serious overload. It will be impossible for him to observe each student as he practices and, at the same time, provide KOR to each student at the proper time.

Chapter 3

THE PRACTICE OF KNOWLEDGE

INTRODUCTION

What is Knowledge?

As used in this series of reports, knowledge refers to symbolic processes. The symbols include words, numbers, mathematical formulas, codes, and pictures. In distinction to the previous chapter, which concerns the practice of the task itself, this chapter deals with the practice of the knowledge components of the task.

These knowledge components typically include such items as the nomenclature, location, and function of equipment; descriptions of step-by-step procedures; special codes, such as map symbols, schematic diagrams, and blueprint symbols; the appearance of various items in the work environment; principles that apply to many tasks; and precautions to prevent injury to personnel or damage to equipment.

Purpose of Practicing Knowledge

Practice of knowledge components will transfer to the learning of the task provided the knowledge is thoroughly learned. This transfer will reduce the requirement for time to practice the task, since the task will be learned sooner. In turn, this may be reflected in a smaller requirement for training equipment.¹

The kinds of knowledge that will transfer to the practice and performance of a task will be those identified as a component of that task in the hierarchy of objectives. The process of determining knowledge and skill components of a task was described in the earlier training objectives report (1), and will not be repeated here.

The evidence is also clear on another point: Little transfer can be expected unless the student has attained a high degree of mastery of the knowledge component. Mastery depends on sufficient practice; one presentation of the information is seldom enough.

A third factor to consider is that it is often much less expensive to practice knowledge than to practice performance. To practice a task requires tools and equipment; in most situations, to practice knowledge requires little more than paper and pencil.

Relation of Practice to Presentation

Clearly, before knowledge can be practiced, it must be presented to the student; however, the methods of presentation may differ. For example, it may

¹The research literature amply supports the proposition that learning the proper kind of knowledge transfers positively to practice of performance. Among the pertinent studies are those of Arnoult (38, 39); Bailey and Jeffrey (40); Baker and Wylie (41); de Rivera (42); Eckstrand and Morgan (43); Gagné and Baker (44); Gagné, Baker, and Foster (45); Hake and Eriksen (46); Kinkade and Kidd (47); McAllister (48); Rossman and Goss (49); Holton and Goss (50); Goss and Greenfield (51).

be presented in small or large segments, before a student practices or concurrently with practice.

For this report, presentation and practice of knowledge are differentiated on the basis of a one-way versus two-way relationship between the student and the media used in presenting and practicing knowledge. In presentation, there is a one-way flow from the media to the student. In practice, a knowledge cue (usually a small amount at a time) is presented; the student responds, and then is provided knowledge of results.

In dealing with practice, then, it will be assumed that small amounts of knowledge will be presented during practice. The function of presentation, as described in the next chapter, will include only the one-way flow of knowledge from an appropriate medium to the student.

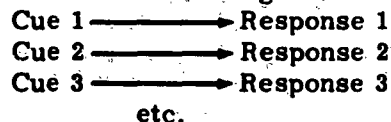
ANALYSIS OF KNOWLEDGE

Before materials and techniques for the practice of knowledge are designed, the knowledge component should be analyzed to determine the proper cues, responses, and KOR so that the student may learn efficiently (Gilbert, 52; Hoehn, 53). The type of analysis to be conducted will depend on whether the knowledge falls into one of several broad classes, described below.

In the design of practice materials, results of the analysis of the knowledge component must be considered. The cues (or a symbolic representation of them) must be presented. Opportunity for a symbolic response must be provided. KOR must also be provided to the student.

Discrimination

If an individual is presented with a series of cues, and each cue requires a different response, the behavior required is a form of discrimination. This situation may be diagrammed in the following manner:



An essential point to emphasize with regard to discriminations is that they are directional. That is, the task requires certain responses to specific cues. Instructors should not require their students to practice such discriminations in reverse order.

It should be noted that in some instances the student does need to learn discriminations both ways. That is, the cue in one situation will be the response in another, and vice versa.

What kinds of knowledge will be in the form of discriminations? Common examples are:

(1) Nomenclature of work objects. Here the picture or drawing of the object will be the cue, and the name the response.

(2) Functions of equipment. The cue is the name or picture, while the response is a statement of the function of the equipment.

(3) Locations of equipment components. Here the cue is a name or a picture, and the response will be the location, either in words or pointing it out in a drawing.

(4) Symbols. Symbols occur in many tasks. Maps, blueprints, electronic schematic drawings, all use symbols that must be learned. Here the cue will be the symbol, and the response either the name or recognition of a picture of what the symbol stands for.

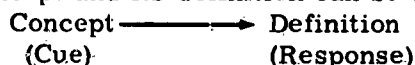
In discrimination learning, sufficient practice should be provided to eliminate errors of discrimination—that is, the giving of an incorrect response to a cue. It will be helpful if the differences between cues are identified and pointed out to the student.

Concept Formation or Generalization

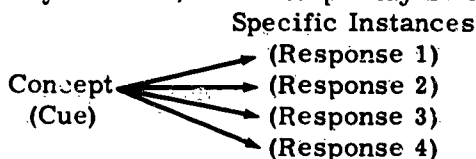
Much of the learning of knowledge involves the learning of concepts. A concept is an abstraction or a term, which may apply to many specific instances or examples.

There are two kinds of knowledge related to a concept that should be learned. First, there are the various defining characteristics of the concept—its definition. Second, there are a number of specific instances of the concept.

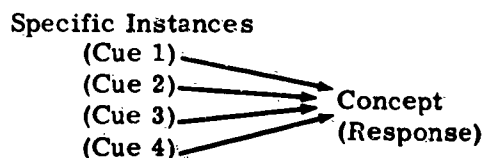
For example, the concept and its definition can be diagrammed as follows:



Of course, if required by the task, the concept may be diagrammed thus:



or



depending on the task requirements.

In learning concepts, the student must generalize particular aspects of the specific instances to form a concept, or must identify what aspects of the specific instances make them belong to a general class.

Another aspect of the learning of concepts is discrimination. Concepts may have to be discriminated from each other, and the general characteristic of the specific instances related to the concept may have to be discriminated from characteristics not related to the concept.

Serial Learning

In the earlier report on objectives (1), it was pointed out that many tasks take the form of fixed or variable procedures. A form of knowledge component appropriate to procedures is the sequence of step-by-step cues, actions, and indications of correct action involved in the task.

Fixed procedures have no deviations or choice points in them. Variable procedures have choice points, in which, depending on the appropriate cue, different chains of activity are chosen. For variable procedures, it is important to identify the cues that require making various choices. Cues requiring a choice of actions to be taken may be analyzed as a discrimination problem for the student.

Fixed procedures and the chain portions of variable procedures are represented as follows:



The detailed task description for the procedure will show whether the particular procedure is fixed or variable in form.

Principles

A principle is a more or less general statement of relationships, usually involving two or more concepts. The concepts included in a principle should be analyzed in accordance with the techniques dealing with cues and responses, described previously.

As Miller (32) has pointed out, unless the principle is anchored in the cues and actions required by the job, it will remain "ivory tower knowledge," of little use on the job. It is, then, necessary to describe the cues in the environment that will call for application of the principle, and the specific actions called for by the principle. Then, when the principle is taught, the student should have a better chance of applying it.

Principles should be analyzed in the following manner:

Cues → (Principle) → Actions

Principles of broad generality will have many specific cues and many specific actions. Care should be taken to identify a reasonable sample of actual cues and actions which might be taken.

FACTORS AFFECTING PRACTICE OF KNOWLEDGE

Knowledge of Results

KOR is as important in the learning of knowledge as in the learning of performance. KOR must be provided to the student when he practices.¹

Two studies (Hirsch, 54; Krumboltz and Bonawitz, 55) have shown that it is generally desirable, in providing KOR during the learning of knowledge, to make the KOR meaningful. That is, instead of simply telling the student "right" or "wrong," or simply giving the correct answer, it is desirable to give an explanation for the correct answer, if practical.

Bryan, Rigney, and Van Horn (56) compared the effectiveness of several meaningful forms of KOR, and found them equally effective. They employed the following forms of explanations:

- (1) Those that gave the trainee the correct definition or description of the chosen alternative.
- (2) Those that provided the principal reason why the chosen alternative was keyed as correct or incorrect.
- (3) Those that pointed out the probable operational consequences of the course of action represented by the alternative.

The course designer should not be surprised to discover that his students do not make use of all the KOR he provides. The student uses any form of KOR he feels is helpful to him. If he is confident he knows the answer, he may pay little attention to the KOR provided him. This does not mean that KOR should not be made available. Students will differ in their need for KOR, and the student's confidence, of course, may be misplaced.

MEANINGFULNESS

The meaningfulness of knowledge is a very important variable in regard to both learning and retention of knowledge (Dowling and Braun, 57; Noble, 58; Sarason, 59). The more meaningful the material is to the student, the easier

¹See the discussion of KOR in Chapter 2.

it is to learn and recall. A foundation of meaningfulness developed through effective sequencing of objectives, promoted through the presentation of knowledge, and carried through the practice of knowledges and skills will be a powerful aid to learning.

The principle of making knowledge meaningful can be applied in many ways in the practice of knowledge. Other things being equal, knowledge that can be related to student experience will be more meaningful than that which cannot. Knowledge that can be clearly related to the learning of a job task will be more meaningful than that which cannot. Knowledge that is organized and classified will be more meaningful than that which is not. Knowledge related to significant student goals will be more meaningful than that which is not.

One practical application of meaningfulness in the practice of knowledge can be found in the research data dealing with the classification and organization of knowledge to be learned. Hake and Eriksen (60), Helson and Cover (61), and Mathews (62) have shown that classifying knowledge into categories helps both initial learning and retention. Another suggestion, made by Hoehn (53), is to avoid lengthy drill sessions on such relatively meaningless material as the nomenclature and the location of equipment or its parts. Instead, combine this practice with the learning of the function of the equipment or its parts. Still another suggestion is to teach the hierarchical structure of the objectives so that the student can see the relationship between practice of a particular item of knowledge and the learning of a task.

Overt and Covert Response

Let us imagine that we have designed materials for practicing knowledge so that the student must respond when presented with a cue. Should we require the student to make an overt response, such as writing his answer, or is it sufficient to ask him just to think his answer?

The research¹ is very consistent on one point: It takes less time for the student to think his answer than to write it (Goldbeck and Campbell, 63; Krumboltz and Weisman, 64; Lambert, Miller, and Wiley, 65; Stolurow and Walker, 66). These studies also generally show that a covert response mode is as effective as an overt mode for initial learning; however, Krumboltz and Weisman found that retention was superior with an overt response mode.

Discovery of Principles

In teaching a principle, is it better simply to present the principle to the student, along with appropriate cues and actions, or is it better to try to get the student to discover the principle himself? Several studies have shown that arranging for the student to discover the principle leads to higher levels of learning (DiVesta and Blake, 67; Forgas and Schwartz, 68; Kersh, 69) or higher levels of retention and transfer (Haslerud and Meyers, 70).

One way to apply this finding is to ask the student to look for and find a principle in the material he has been given. He can be given various kinds of prompts and hints. There is a possibility, however, that the use of discovery may be more time-consuming than simply presenting the principle to the student.

Distribution of Practice

Whether practice situations are distributed throughout training or grouped with little interval between practice periods is less significant in learning

¹Most of the recent research on this point has been associated with programmed instruction.

knowledge than in learning performance (Underwood, 71). In the practice of knowledge, the only situation in which distribution of practice has much effect is when there is interference between the responses. If a student tends to give erroneous responses to specific cues, the interval between trials should be kept short, on the order of a few seconds.

Other Factors

Some additional factors have been found to influence the learning of knowledge in specific circumstances.

Arnoult (72) taught subjects to recognize spatial patterns by one of several methods: the reproduction of patterns from memory, general questioning about patterns, specific questioning about patterns, and observation of patterns. The reproduction method was clearly superior to the others, while the questioning methods were relatively ineffective.

Notetaking during lectures may be considered a rough form of practice. In one study that involved comparison of two groups (Eisner and Rohde, 73), one group took notes during the lecture and studied later, while the other took notes and studied immediately after the lecture. There was no difference in achievement between the groups. McClendon (74) compared the following procedures: taking no notes on a lecture, taking notes on the main points only, taking detailed notes, and taking notes in the student's usual manner. There were no differences in achievement or retention because of different notetaking practices.

TECHNIQUES FOR PRACTICING KNOWLEDGE

Basic Patterns for Practicing Knowledge

The most usual pattern for the practice of knowledge is to present the cue (or a symbolic representation, such as a drawing, diagram, photograph, or word(s)), and require the student to produce (or think) the response, followed by KOR. There are special considerations that apply to specific kinds of practice (Hoehn, 53).

In discrimination learning, it is important that the attention of the trainee be directed to the critical aspects of each cue that differentiates it from other cues.

In the learning of concepts, the trainee should be presented with cues in which the common characteristic that defines the concept appears, but in which other features vary as they would be expected to in the job environment. The trainee should receive practice in which he discriminates between cues that contain the common characteristic and those that do not.

In the learning of procedures, an effective practice situation can be developed from drawings or photographs of equipment panels and consoles. This will enable the student to practice knowledge not only of the location of controls and indicators but of the sequence of actions.

Lengthy procedures can often be subdivided into portions that have a common name and purpose. Teaching the student this information along with the procedure will help him organize the learning and will make it more meaningful.

In the teaching of principles the possibility of learning by discovery has already been mentioned. Care must be exercised to provide the student with a reasonable sample of cues and actions to which the principle is related.

Self-Instructional Techniques

Within the field of programmed learning, a variety of techniques have been developed to permit the student to practice knowledge by himself and at his own

rate.¹ These include linear programs, branching programs, and various combinations of each. The self-instructional methods permit the instructor to monitor progress of the class as a whole and to work with individual students.

Various types of worksheets and workbooks can be developed to permit student practice of knowledge within the guidelines of this chapter. These can be organized to present cues, permit the student to respond, and provide knowledge of results. They may be supplemented by a variety of response devices, such as punchboards and special answer sheets (Pressey, 84; Schutz and Whittemore, 85).

Development of specific methods for providing practice within a self-instructional framework, using the guidelines of this chapter, is limited only by the ingenuity of the instructional system designer.

Classroom Feedback Methods

Practice of knowledge can also be provided through classroom feedback. These techniques involve more instructor activity and control of the practice session than do the individualized methods. They allow students to practice at a pace set by the instructor, and permit a considerable degree of control by the instructor. In general, they require the instructor to present questions and problems to the class, followed by an answer from each student, followed by KOR from the instructor (feedback).

Several electrical devices have been built to provide classroom feedback. Usually, after the instructor asks a question, or presents a slide with a question on it, the student presses a button or other control indicating one of several responses. A control panel shows the instructor how many students gave the correct response. He can then provide KOR.

A simpler version of the same technique is to give each student four or five cards, each a different color. When the instructor asks a question, the student holds up the card that represents the alternative he has selected. The instructor then provides KOR.

Student-Coach Method

The student-coach method permits considerable student activity under general monitorship of the instructor. In the student-coach method, one student is the learner, while another student asks questions and gives KOR. Naturally, the coach must have the appropriate materials to use.

It is suggested that the coach and student alternate roles in successive trials, so that each trainee can be both coach and student. It is very likely that the trainees will learn during both roles.

Interest may be added by keeping score on the number of questions answered correctly by the student on each trial. Each student can informally compete both with himself and with the other member of the pair.

The Instructor

All of the methods described in the preceding pages are intended to eliminate the problem of overloading the instructor during the practice session. The instructor cannot observe all that is going on in any degree of detail, and provide appropriate KOR, if he has more than two or three students.

¹The reader is referred to studies by Gilbert (52); Green (75); Lumadaine and Glaser (76); J.ysaught (77); Melching, *et al.* (78); Ofiesh and Meierhenry (79); Schramm (80); Stolurow (81); Melching, *et al.* (82); DA PAM 690-21 (83).

Chapter 4

THE PRESENTATION OF KNOWLEDGE

THE ROLE OF PRESENTATION

A Contrast With Practice

During the practice of both performance and knowledge, the student responds actively, and receives KOR. In the presentation of knowledge, he is relatively passive. He receives the presentation; it is to be hoped that he pays attention; but he does not respond and does not receive KOR.

It is easier to design situations for presentation than for practice. The lack of interaction between the student and his environment poses limitations on the effectiveness of presentation as a means of teaching; however, presentation can contribute significantly to the development of performance.

Purposes Served by Presentation

Providing Orientation. It is generally useful to provide the student with an overview of the job he is training for. This permits him to relate specific training activities to the overall purpose of his training. Provision of this orientation is useful even though no specific training objective may be served by it.

Providing Organization and Meaning to Knowledge Items. Meaningfulness, which was discussed in connection with practice of knowledge, is also an important factor for the presentation of knowledge, particularly because of the student's passive role in presentation. Presentation techniques can be designed to provide the student with a suitable framework of organization and meaning that will help him learn specific knowledge content.

Guiding Practice. In the initial stages of practice of either performance or knowledge, presentations can guide the student's practice so that he makes fewer errors. For example, picture guides including both step-by-step procedures and appropriate photographs of the equipment were developed in HumRRO SHOCKACTION research (MacCaslin, Woodruff, and Baker, 86). These guides helped the students practice effectively. A variety of devices, which include both slide and sound presentations, are available to guide practice. Demonstrations, of course, are widely used for this purpose.

Presenting Knowledge to be Learned. In most training courses, a great deal of time is spent presenting knowledge to be learned, using lectures, demonstrations, films, and so forth. Although students do learn from presentation alone, there are limitations on the amount that can be so learned. Learning is more effective when the student is actively responding and receiving KOR than when he is passively receiving information.

A related problem in presentation without student response is the difficulty in determining immediately whether the student understands the message, whether it is being delivered too fast or too slowly, or whether the student was paying attention.

Methods and Media

Among the wide variety of media and methods developed for the presentation of knowledge are lectures, demonstrations, films, television, training aids, slides and tape recorders, and books. Previous research evidence suggests that, although each has special capabilities, these methods and media are equally effective; therefore, a major factor in the selection of methods and media is relative cost. Cost consideration should include not only initial cost, but also replacement and repair of equipment.

GENERAL GUIDELINES FOR DESIGN OF PRESENTATIONS

Meaning and Organization

It is important that meaningfulness and organization be built into the presentation. Meaning can be designed into it by:

- (1) Providing overviews of the job.
- (2) Relating specific knowledge to task performance.
- (3) Relating specific knowledge to trainee experience, interests, and goals.

Much of the material presented will have a natural organization. Where this is the case, the natural organization should be followed. Otherwise the material should be organized or classified by the instructional system designer. Organization of material can be achieved by the use of:

- (1) Outlines showing the structure of the knowledge being presented.
- (2) Topic headings showing the main points being presented.
- (3) Charts and graphs showing the organization of the hierarchy of objectives.
- (4) Repetition during the presentation of the main points or major outline headings.

A Set to Learn

It is necessary to create in the student a set to learn, that is, a motivation to pay attention to, and to learn, the material needed for job performance. There is much evidence that students will generally learn what they think they should, which is not necessarily what they were supposed to learn. What is needed, then, is to induce in the student a set to learn, and also help him identify the material that is most important.

Among the several methods that can be used to create this set are the following:

- (1) Providing the student with a list of the objectives.
- (2) Administering a short quiz or test before the presentation.
- (3) Notifying students that they will be tested on the material presented.
- (4) Giving a preview that points out the main topics to be presented.

Assuring Audience Reception

Whereas in the practice of performance and knowledge the student makes responses that can be corrected if they are wrong, during a presentation the student is simply watching or listening. The human lecturer or demonstrator or the presentation device does not know whether the audience is receiving the message. Material may be presented too fast, too much new material may be presented at one time, or the language and pictures may be confusing.

Since there is no feedback from the student during the presentation, the presentation should be tested to determine whether the message is clear and appropriately paced for the student audience. The general pattern of such a test would be as follows:

- (1) Present a short section of the message.
- (2) Ask typical students questions to determine whether they received the part of the message.
- (3) Repeat steps 1 and 2 until the total message has been tested.
- (4) Analyze the answers to these questions.
- (5) Revise the presentation, if necessary.
- (6) Retest or revise the presentation until it clearly communicates to the majority of the students.

TRAINING FILMS

Extensive research has been conducted on the use of films for training, and certain research findings are of interest to the overall planner of the instructional system. The most comprehensive series of studies is that conducted by the Instructional Film Research Program of Pennsylvania State University (Carpenter, 87; U.S. Naval Training Device Center, 28). The following material is based primarily on these studies.

Implications for the Instructional System

Films can present knowledge with equal or greater effectiveness than other comparable methods and have a wide variety of applications. They have been used to teach factual information, foreign-language vocabulary, motor skills, and mental hygiene, and to instill attitudes.

Training films are most effective when they are designed to accomplish specific training objectives with a specific audience. For example, films with general and rather superficial content aimed at a wide audience are likely to be less effective than films with specific content, related to objectives, and aimed at an audience with known characteristics.

Students can learn how to learn from films. A later section on suggestions for film use will describe ways by which the student can be taught to learn more effectively from films.

Training films can be produced inexpensively without sacrificing effectiveness. Many of the techniques used in films designed for entertainment need not be used because they do not contribute to training. Among these are dramatic sequences, special camera effects, and color.

Implications for Film Production

Research has suggested a number of ways to increase the effectiveness and reduce the cost of training films.

First, sound principles of learning must be applied in the film. A number of these points will be noted as similar to those described in other contexts; some will also suggest ways in which practice of either performance or knowledge can be integrated with film presentations.

The need to consider the audience has already been mentioned. More specific suggestions are:

- (1) Show performance on the screen as if the learner were doing the job himself. Show him what he would see.

(2) Present information either by picture or sound at a rate slow enough to permit the student to receive the message. Do not introduce too many new ideas. Avoid packing the sound track with too many words per minute.

(3) Introducing unnecessary new names or technical terms in a film places an additional burden on the student and may interfere with the learning of a performance.

(4) Avoid too succinct a treatment of a topic. Presenting only the barest essentials or a very rapid coverage may be completely ineffective.

A number of suggestions can be made to apply learning principles already described:

(1) Use repetition. Plan the organization of the film so that important concepts or sequences are repeated. The repetition of entire films, or parts within a film, is a very effective means for increasing learning. In addition, the important points in the film should be summarized sufficiently completely to serve as a review and repetition.

(2) Increase the organization of separate facts by using an outline in both titles and commentary.

(3) The meaningfulness of the presentation to the student can be increased by using the second person (you) in commentaries, speaking directly to the student, and avoiding the passive voice.

The learning of skills can be assisted materially by using films to guide practice. For example:

(1) Short film loops, which can be repeated as often as necessary, seem to be an effective way of teaching skills.

(2) Learning performance will be improved if the student practices a skill while it is being shown on the screen, provided the film develops slowly enough, or if periods of time are planned to permit the student to practice without missing new content.

Many of the techniques used in dramatic or entertainment films do not add to the training effectiveness of films. Films that do not utilize these techniques can be produced quickly and inexpensively. For example:

(1) Special effects designed as attention-getting devices do not improve learning.

(2) Optical effects, such as wipes, fades, and dissolves, do not contribute to teaching effectiveness.

(3) The addition of stereoscopic vision in one experiment did not improve the learning of a motor skill.

(4) Research does not show that use of color increases overall learning.

(5) Preliminary research suggested that music does not increase the effectiveness of a training film.

(6) The use of dramatic sequences, comedy, or realistic settings in films designed to teach factual material does not increase learning.

Suggestions for Film Use

In designing training situations in which films are going to be used, adherence to certain practices, which are adaptations of familiar principles, has been found to increase the amount of learning from films.

First, it is necessary to develop in the student a set to learn from films:

(1) The students should be told firmly that they are expected to learn from the film. They should be tested after the film and be informed in advance that they will be tested.

(2) Students should be given printed study guides to use before and after the film.

(3) Students should be discouraged from taking notes, because it distracts their attention.

(4) The purpose and importance of the film should be explained.

The following general suggestions are relevant for the effective use of films to promote learning:

(1) Repetitive showings increase learning.

(2) Pretesting and posttesting with provision for KOR add to the effectiveness of films.

(3) One showing of a film describing a complex skill may not be enough. It is desirable to show the film in the area in which students are practicing so that they can refer to the film as often as they need to. This can be done by rear projection daylight screen. The students should be placed within 12 screen widths of the screen, and within 30° of the center line.

(4) A skill can be partly learned through mental practice. Students should be encouraged to imagine they are performing the skill while they are watching the film.

INSTRUCTIONAL TELEVISION

Instructional television, like other media, must be considered in the light of cost, effectiveness, and special capabilities to solve particular problems.

The material in this section has been taken primarily from the Instructional Television Research Reports of the U.S. Naval Training Device Center (89). It is strongly recommended that agencies using instructional television study that report carefully.

Criteria for Using Instructional Television

The report cited above describes 13 criteria by which systematic judgments can be made concerning the use of television for presenting lessons:

(1) For presentation or demonstration, television is applicable. For practice, it is not.

(2) If two-way communication between instructor and student is necessary, television is not suitable. (Both of these criteria reflect the fact that television is a medium for presentation.)

(3) If rapid dissemination of information, reaching many men early in training, or rapid distribution of new information is necessary or urgent, television is favored. Otherwise, television may be considered optional.

(4) If there is a shortage of qualified instructors, television is favored. If not, television is optional.

(5) If the training situation involves physical risk or danger, television is favored. If not, it is optional.

(6) If training aids or actual equipment is in short supply, television is favored. If supplies are ample, television is optional.

(7) If training aids and equipment are difficult to move because they are large, heavy, or unwieldy, this circumstance favors television. If they are easily moved, television is optional.

(8) If closeups are necessary in viewing training, this is a plus factor for television.

(9) If color is an essential element of the presentation, color television is required. Otherwise, black and white can be used.

(10) If making a sound record is very desirable, television can be used to prepare tapes or kinescopes. If the sound record is not important, television is optional.

(11) If much training time is lost in moving from one training area to another, television is desirable. Otherwise, it is optional.

(12) If weather interferes with presentation, use of television can solve this difficulty.

(13) If material being presented is classified, broadcast television cannot be used, although classified matter can be transmitted via cable.

The report previously cited shows how these criteria can be applied in deciding as to the applicability of television to particular lessons.

The points just set forth can be summarized as follows:

(1) Television is a presentation medium.

(2) It is an amplifier of presentations. It can give wide coverage to both good and poor presentations. It can amplify through closeups material that would be difficult to view directly.

(3) It is a form of automation, with the advantages and limitations of automation.

(4) By tapes and kinescopes, it provides a means for making repeatable presentations quickly.

Television and Films

Much of the research conducted on the preparation and use of training films is directly applicable to television. For instance, the use of dramatic special effects does not add to the training effectiveness of television. Television presentations can be made more effective by integrating them appropriately with practice. The reader interested in television is referred to the previous section on films for material on this point.

Technical Matters

Television is a medium with a high initial cost. It requires a group of trained operators and maintenance personnel. There are many technical matters concerning equipment and its use, and production techniques that must be understood. These are beyond the scope of this paper. The U.S. Naval Training Device Center report (89) treats, intensively, the production techniques appropriate to training. Additional sources are included in the list of references for this chapter.

Training vs Entertainment

One management problem concerned with the use of television requires special consideration. It is likely that the key production personnel acquired by a training agency will have been trained and experienced in television as an entertainment medium. They will naturally want to employ these entertainment techniques for training. However, research results clearly show that these methods do not contribute to training, and they increase costs unnecessarily.

TRAINING AIDS

Training aids are generally used for presenting knowledge for pictorial, graphic, or organizational content. They can be used effectively for providing students a visual map of system flow and of relationships between system components in complex equipment (Aukes and Simon, 90). Aukes and Simon also

show the importance of not presenting unnecessary information. If a series of conditions or subsystems is being taught, it is better to prepare a series of aids, each presenting only that information relevant to a specific condition, than to have an overall aid that presents all information at all times.

Training aids are generally used in conjunction with lectures, and some overlap between the material presented by the lecture and that provided by the aid is likely.

In studies of the relative effectiveness of operating mock-ups, nonoperating mock-ups, cutaways, animated panels, charts, and symbolic diagrams, Swanson (91) and Swanson and Aukes (92) found no significant differences. Torkelson (93) compared the use of mock-ups, cutaways and transparencies and found no difference.

Vris (94) and Silverman (95) found results which suggest that three-dimensional and animated aids may be superior to presentation of knowledge components of skilled performance.

On the basis of this evidence, it is reasonable to use the less expensive aid, except where relatively skilled performance is to be developed.

TAPE RECORDINGS

Since a lecture is primarily an auditory medium, why not substitute a tape recording for the lecture? Tape recordings have generally proved to be as effective as live lectures. For example, Newman and Highland (96) compared four methods of presenting a 21-hour course in radio over a four-day period. The methods were: an instructor (rated above average in ability); tape recordings and workbook; chapters in a notebook; and tape recordings and slides. No overall differences were found; the mass media were as effective as the instructor for the first two-thirds of the course, while the instructor was superior for the last third. In two separate studies of college teaching, Popham (97, 98) compared tape recordings with live lecturers and found no difference. Follett (99), using military trainees and content from Army basic military training, found no difference between recorded and live lecturers. These studies indicate a tape recording is an acceptable substitute for a live lecture.

WRITTEN MATERIALS

Assuming that the students are reasonably proficient readers, textbooks and other written materials are appropriate for presenting a wide range of content.

Organization

The use of techniques for imposing meaningful organization on all training content has been emphasized at several points in this report. Written materials are no exception. Postman (100) shows that learning principles of organization can increase the amount of subject matter learned.

Ausubel (101) and Ausubel and Fitzgerald (102) have shown the value of what they call the "advance organizer." This is an introductory statement that describes the general concepts to be presented in more detail later in the training.

Klare, Mabry, and Gustafson (103) compared the effect of underlining and not underlining key words. They did not tell their subjects the purpose of the underlining. Able students were helped, but less able students were hindered. Their research indicates the importance of familiarizing students with any organizational system used.

It does not seem to make much difference which organizational system is used. Using two passages from Air Force correspondence courses, Christenson and Stordahl (104) compared all possible combinations of the following: outline at the beginning of the passage, summary at the beginning of the passage, summary at the end of the passage, underlining of main points, headings in statement form, and headings in question form. They found no differences in the effectiveness of these treatments.

Readability

The ease with which written materials can be read by readers of differing educational levels can be measured in several ways. These are discussed in considerable detail by Dale and Chall (105). Klare, Mabry, and Gustafson (106) and Rubenstein and Aborn (107) have shown that the more readable the material, the easier it is to learn.

Most techniques for increasing the ease of reading can be reduced to two basic rules: First, use short, easy words; second, use short sentences. The value of techniques for measuring readability is to provide the writer with a rough index as to how difficult the material is that he is preparing. Naturally, when the writer is preparing technical materials, it is impossible to avoid technical words. However, care should be used to keep the nontechnical content as simple as possible.

THE LIVE INSTRUCTOR

Traditionally the live instructor is an important medium for presenting knowledge; however, research clearly shows that he has no special advantage for this function. The principal advantage to using a live instructor is that he is traditional: Students are used to him.

The size of his class is limited by the range of the instructor's voice. With automated techniques, there is practically no limit to the number of students who can be reached.

The principal disadvantage of live instructors is that they are variable. Instructors differ in their ability to speak clearly and distinctly. They differ in the rate at which they speak. Some are more concerned with impressing students with how much they know than with teaching.

The same instructor is also uneven from time to time. He may become bored with teaching the same material over and over again. He may fall behind schedule and attempt to catch up by talking faster.

Excellent guidance is provided the live instructor by Department of the Army Field Manual 21-6, Techniques of Instruction (108).

OTHER FACTORS

Size of Class. There seems to be no particular limit to the number of students who can receive a presentation at one time, as long as each student can receive the message.

Repetition. Repetition of presentations, or of main points in a lesson, is desirable. This factor is mentioned in the section on training films. Anneser and Beecroft (109) and Beecroft and Anneser (110) found that repeating the main points in a lecture was effective in increasing student achievement.

Chapter 5

MANAGEMENT OF STUDENTS

The purpose of the student management function is to keep the student working productively at the task of learning. Topics discussed in this chapter include student ability and motivation, adjustment to individual differences in aptitude, maintenance of student interest in learning, and control of avoidable absences.

All training programs have some kind of student management function, based primarily on monitoring by the instructor and the threat of punishment for absences or obvious and flagrant inattention. It is suggested not that such monitoring be eliminated but that it be supplemented by other, more positive techniques.

THE STUDENT

Students differ in many ways, some of which are of considerable importance to the design of instructional systems. Student characteristics are discussed here to lay an appropriate foundation for designing the student management function.

In order to utilize the points discussed in this section, certain information about the students must be collected. This should include:

(1) Range of aptitude, to let the designer know how much adjustment will need to be made for individual differences.

(2) Previous educational level and range, which indicate both the level at which presentations and practice may be aimed and the need to adjust for individual differences.

(3) Attitudes toward previous education, to indicate whether there is a requirement to make the material especially easy to learn.

(4) Work experience and hobbies, to provide information to guide selection of examples and illustrations, and to provide clues for the identification of activities that may serve as reinforcers. (See section on "reinforcement".)

Aptitudes

The Nature of Aptitudes

A common complaint among trainers is that their students are not properly selected. Of course, everyone wants students with high aptitude. Properly motivated, they practically train themselves. The difficulty with raising aptitude prerequisites is that bright people are at a premium; there are seldom enough of them to go around.

An aptitude area score is a weighted sum of the scores from a large group of tests. These scores are developed on the basis of many years of scientific study of the relationship of test scores to later school performance, and a great deal of statistical analysis. Department of the Army Pamphlet 611-2, Army Personnel Tests and Measurement (111), describes these test concepts in more detail.

The tests that result in the area scores reflect several different kinds of characteristics of the student:

- (1) Basic abilities, identified through many years of study and analysis.
- (2) Previous learning of content related to school performance.
- (3) Previous experience in certain areas, through tests of knowledge and biographical information.
- (4) Interest, as measured by knowledge and biographical information.

These tests are combined appropriately to maximize the prediction from aptitude area to a group of related schools and training programs.

There is a certain amount of correlation between the area scores. This means that students who are high on one area tend to be high on the others. Despite this, there is more room for differences to appear on the several area scores than there would be if only one test were used, as was done during World War II with the Army General Classification Test.

The testing field is one of the oldest applications of scientific research on people. Experience to date suggests that school success can only in part be predicted from aptitude test scores. Roughly, the accuracy of prediction using such scores is not more than twice that of random prediction, leaving at least half of the variation connected with school success unpredicted. This means that predictions are made in terms of probabilities. Though not certain, it is more probable that a high-aptitude student will succeed, and that a low-aptitude one will fail.

Individual Differences in Aptitude

In every course students will differ in aptitude, with some able to learn much faster and more easily than others. The extent of these differences will vary from one training program to another. The wider the spread of aptitudes, the greater the need for adapting the training program to students of differing levels of ability. It is important for training officials to know the range of aptitude existing among their students.

A wide range of aptitude in a group of students creates severe problems for a course in which everyone proceeds at the same rate. If the course is pitched to the bright students, the slow students will be lost; if it is aimed at the slow students, the bright ones will be bored because of lack of challenge. The instructional system should be adjusted to take differences in aptitude into account.

Motivation

Motivation is an important consideration in designing the student management function. A student's motivation is believed by many training officials to be closely linked to how much intrinsic interest a training activity has for him.

On the other hand, many things can be done within the instructional system to significantly increase the amount of effort the students will put forth. The principal emphasis of this chapter is on those things that generally can be controlled by the system designer.

Fundamental Ideas in Motivation

(1) A motive is a characteristic that initiates, changes, or sustains behavior. The instructional system designer is concerned with initiating and sustaining effective learning behavior by the student.

(2) Man is a continuously wanting being. If he is satisfied in one area, he develops needs in another.

(3) Satisfied needs do not motivate. There must be a certain lack of need satisfaction to initiate, change, or sustain behavior.

(4) The same need may be satisfied in different ways, both by the same individual and by different individuals. Some people who want money work for a promotion; others rob banks.

(5) A given mode of behavior may satisfy more than one need. There are several reasons why an individual will work hard to learn. He may be trying to attain social prestige over other students. Or, he may feel he can gain a promotion.

(6) The individual's attempts at need satisfaction will not always please his instructor or his supervisor. Often an individual will behave in ways that may annoy or disturb his supervisor.

Major Classes of Needs

A general framework in terms of which the concept of motivation may be understood derives from Maslow's (112) characterization of the hierarchical nature of needs, and the notion that it is unfulfilled needs that motivate behavior (including learning behavior). Where high-priority needs are satisfied, needs of lesser priority become activated, generally in order.

In the first class, that with the highest priority, are the physiological needs—for food, water, air, sleep, et cetera. If these needs are unsatisfied, the individual will be occupied with attempts to satisfy them. Once they are satisfied, the higher needs emerge, and will dominate the individual.

The next level of needs is called the safety needs. These include avoidance of physical harm, assault, and death, and a preference for familiar and safe situations.

The next set of needs is that of the needs for belonging and love. If both physiological and safety needs are satisfied, the individual will strive for social relationships and affection.

The next group of needs is concerned with self-esteem. These include desires for strength, mastery, achievement, and competence. They also include respect and prestige given by other people.

Finally, there is the need for self-actualization, for making the most of one's capabilities.

In general, then, the needs most closely related to intrinsic motivation to learn are relatively high in the hierarchy. They cannot be expected to appear spontaneously unless physiological, safety, and belongingness needs are reasonably satisfied.

Frequently, if an individual has been deprived for a long time of need satisfaction at a certain level, these needs will continue to dominate his behavior even though the situation has changed.

Satisfaction of the physiological, safety, and belongingness needs for a sufficient number of students to enable them to be motivated by higher level needs may be beyond the capability of the instructional system designer. In a reasonably well-ordered society the physiological and safety needs are usually well satisfied. If they are, attention should be directed to arranging for the satisfaction of the belongingness needs if those concerned with self-esteem and self-actualization are to appear and be the motivational basis for training.

Previous Experience

The student's previous experience can significantly affect his motivation for training. Two aspects of his experience—education and work experience (including hobbies)—are especially important.

His particular educational experiences will have a serious impact on the student's attitudes toward training activities during his military service. If a student has made good grades and achieved a reasonable degree of success in school, he will probably approach his military training with confidence and a favorable attitude. On the other hand, if he has a long history of academic failure, he will probably approach his military training with a lack of confidence and a severe distaste for studying.

The student's previous work experience and hobbies, if any, and the sports in which he engages can provide a basis for making the new material in a course more meaningful. If a relationship can be developed between the new material and the student's previous experience, the new material can be made easier to learn. This is illustrated by the fact that many an instructor has found that examples and analogies fell flat because the student's background did not permit them to be understood.

General Implications

(1) Each student is unique. A training system that receives a variety of students, each different from the others, and exposes them to identical training activities will result in a range of proficiency levels. The way to standardize the results of training, which is the fulfillment of the objective, is to give each student an appropriate amount of presentation and practice. Some will require more than others.

(2) A certain lack of need satisfaction is necessary to motivate students. Satisfied needs do not motivate. It is therefore necessary to design a situation in which students will have mildly unsatisfied needs, which can be satisfied by effective progress in the instructional system.

(3) Avoid severe frustrations that activate lower level needs. If students are subjected to severe frustrations of physiological, safety, and social needs, they can be expected to devote their time, energy, and attention to these, rather than to the content of the training.

One kind of safety need is the need for assurance as to what students must learn. This can be satisfied by letting the students know the objectives.

(4) Unfavorable attitudes toward training can be changed. Attitudes serve a variety of functions. One function, as pointed out by Katz (113), is to reflect the effects of previous success and failure. People tend to develop favorable attitudes toward situations and things that have satisfied their needs, and unfavorable attitudes toward those that have frustrated need satisfaction.

Unfavorable attitudes toward learning, developed through failure in previous educational experience, can be changed by making the learning so easy that success is guaranteed. This point is supported by the work of McKee (Ofiesh and Meierhenry, 79), who has been operating a self-instructional school, using programed instruction, in a correctional institution. When school dropouts began learning in programs designed with a very low error rate, a significant increase in intellectual interests was noted, by both McKee and the warden. The student inmates began to ask for books and use the library, which few had done before. Naturally, a reasonable level of aptitude is necessary before this can happen.

REINFORCEMENT

The Nature of Reinforcement

Reinforcement is the process of providing reinforcers. A reinforcer is a cue that makes more likely the recurrence of the behavior a student was engaged in just before the delivery of the reinforcer. In other words, the student who is doing something when the reinforcer appears is more likely to do that same thing again. Reinforcers are powerful controls on the behavior of individuals. Proper management of reinforcement is a very significant aspect of the management of students function.

It is first necessary to decide what behavior is to be reinforced. This behavior is the one that leads to the attainment of an objective, both task and component levels, within a reasonable period of time.

The second consideration is what to use as a reinforcer. Any need satisfier can serve as a reinforcer. Most students in military training situations find they seldom have time to do the things they want to do. Time off, then, is a very effective reinforcer. Rest periods are another (Azrin, 114). Such reinforcers as priority in the mess line, passes, and freedom from unpleasant details have been found to be effective (Findlay, Matyas, and Rogge, 115).

Another source of ideas for possible reinforcers is suggested by Premack (116). Premack suggests that if Behavior A is more probable than Behavior B in a given situation, A can serve as a reinforcer for B. Lloyd Homme and his associates¹ have taken this idea as a guide for developing a number of practical techniques for use in reinforcing progress in learning.

Through questioning and observation of students during their free time, a number of highly probable behaviors are identified as reinforcers. These behaviors are listed on a Reinforcing Event Menu. The Menu gives the student a choice from among several possibilities. It also avoids the possibility that one particular activity selected by the system designer may lose its reinforcing power after continued use.

As applied by the Homme group, the student successfully completes a certain amount of learning activity. He then selects an activity from the Menu that he would like to engage in, and is permitted to do so for a fixed period of time. The school is separated into a reinforcing event area and a work area; this allows reinforcement without disturbing those who are working. Students are also reinforced for a prompt return to the work area.

Another refinement is to make a "contract" with the student. Each reinforcing activity has a price placed on it, in terms of the amount of work required before the student can engage in the activity. The student selects the reinforcing activity, and is informed of the amount he must learn. Then, when the work is completed, he is immediately released to engage in the chosen activity.

Despite the fact that the student spends a considerable portion of each day in the reinforcing event area, the experience has been that students do much more work under these conditions than when all of the time is used in work on the learning activity.

In the sections dealing with the practice of performance and practice of knowledge, the importance of KOR was stressed. In the management of students KOR sometimes serves as a reinforcer, but sometimes it does not.

¹Presentation at the 1966 meeting of the National Society for Programmed Instruction, St. Louis, Mo.

Reward and Punishment

Rewards to students for attaining objectives generally have a straightforward reinforcing effect. Punishment, on the other hand, has a less predictable effect. Sometimes it stops undesirable behavior (but perhaps only for a brief period); sometimes it actually reinforces the undesirable behavior. Often punishment generates emotional reactions that interfere with the learning process.

Clearly, reward for attaining objectives is superior to punishment for not attaining objectives. Yet, at present, management of students tends to operate on the basis of punishment; when this is the case, the picture is one in which, for example, the student who fails to work hard in class or is not attaining the objectives may be restricted or placed on compulsory study hall. A more constructive approach is possible if the student is able to perceive the situation as one in which he will be rewarded for success, rather than one in which he will be punished for failure.

Instead of using a pattern of restricting those who do not do good work, or making attendance at study hall compulsory for those who fail, for example, it is quite possible to operate in a pattern in which study requirements are initially placed higher for all students. It is then feasible to reward successful students by giving them passes or excusing them from portions of the supervised study, while at the same time the less successful student is required to put in the additional study time without the context of failing or being punished.

Schedules of Reinforcement

The delivery of a reinforcer upon the satisfactory achievement of an objective will generally develop and sustain the behavior of working effectively toward learning. If reinforcement is delivered at each successful response by the student, the behavior will be developed quickly.

If reinforcement is stopped, then the behavior will shortly stop. This is called extinction. Thus the problem for the instructional system designer is to make effective learning behavior resistant to extinction. The solution is partial reinforcement. At the beginning of training, deliver some form of reinforcement very frequently. Then gradually reduce the proportion of times at which the reinforcement is delivered to about one time to each five successful performances. This will sustain the behavior very well, and make it very resistant to extinction, in situations when delivering a reinforcer every time throughout training is impractical. One should be prepared for some resentment on the part of the student when reinforcement is first skipped.

The schedule of reinforcement can also affect the amount of work performed by the student. Ratio reinforcement is given after a certain number of successful performances. Interval reinforcement is given after the passage of a certain amount of time. Ratio reinforcement yields a high rate of work. Interval reinforcement, on the other hand, yields a slow rate of work; not much is done early in the period, but speed picks up as time for reinforcement approaches.

Clearly, ratio reinforcement is superior to interval reinforcement for management of students. Yet most student "breaks" in existing courses come at definite times, unrelated to progress (for example, every 50 minutes).

ADJUSTMENT FOR INDIVIDUAL DIFFERENCES

Because students are different, it is impossible for all of them to attain the same level of proficiency if identical learning experiences are provided for

each student. For effective and efficient learning, it is generally necessary to make adjustments for individual differences.

Ability Grouping

One way of adjusting for individual differences is, of course, to group students by ability and provide different courses for each aptitude level. The feasibility of this procedure depends on being able to identify students of differing abilities in advance, and on having enough students to make multiple courses economical.

In the educational literature, ability grouping is referred to as the track system in the United States, and as "streaming" in England. Results from ability grouping have been mixed, and have frequently not been effective. See, for example, Rudd (117).

When the performance of high-, low-, and medium-aptitude trainees was compared after four and eight weeks of basic training (Cline, Beals, and Seichman, 118), high-aptitude trainees in the four-week course did as well or better than students in the eight-week course in tests of military information and performance, but not as well in rifle marksmanship and physical fitness. In this case, additional training in marksmanship and physical fitness for the high-aptitude trainees might still have resulted in a course shorter than eight weeks.

Recycling

Many standardized, fixed-length courses really become variable-length courses when students who have failed a portion of a course are required to repeat it. This repetition is called recycling.

Recycling, if used, should be decided on as quickly as possible. In courses in which certain objectives are prerequisites for later work, failure to attain the objectives can seriously impede further progress. If the decision to recycle is made immediately, the work can be repeated quickly, and the student may be able to progress without serious difficulty. Delaying a decision may mean that the student accumulates a lengthy failure experience, the effects of which are extremely difficult to overcome.

To some extent recycling is a punishment. The student has been separated from his friends and is required to make new ones. It is clear proof of failure, and the failure is obvious to the new class.

Recycling, of course, depends on the ready availability of another class into which the student can go. If classes start only a few times each year, it is not feasible.

Fixed Overall Length, Variable Time

Another way of dealing with individual differences is to establish a course with a given length, in terms of days, but with variable times spent in learning for different students each day. For example, if the basic schedule required students to spend all day and a few hours each night in training, including Saturday, those students who achieved the objectives in a reasonable time might be excused from study at night and on Saturday. Time off can, thus, serve as a reinforcer.

Continuous Progress

One method of dealing with individual differences which has been applied in the public schools is the continuous progress plan (Read and Crnkovic, 119),

sometimes referred to as the ungraded school. Each student learns at his own pace. A variety of techniques are used, each aimed at permitting the student to learn at the rate best for his capability. In this plan, reinforcers must also be provided, for speed of progress as well as simply for achievement of objectives.

Student-Controlled Learning

Several studies (Caro, 120; Milton, 121; Mager in Ofiesh and Meierhenry, 79; Aldrich, 122) have shown that mature learners do not require formal classes or management to learn effectively. College students who were given a semester's assignments to do on their own have done as well as those who attended class. Students provided with specified objectives they must attain have learned much faster than those undergoing formal training. Army Personnel Specialists learned as well in this manner as when attending classes.

This method requires certain arrangements:

- (1) The students should be provided the training objectives.
- (2) All information and practice materials required for attainment of the objectives must be made readily available to the student any time he wants them.
- (3) A rigorous testing plan must be devised.

Student-controlled learning might be an especially feasible plan for officer courses. Officers are mature and responsible students. In a given course, it may be likely that each officer will have had previous experience in a particular area covered by the course, but that different officers will have had different experiences. Thus, the amount of effort required to meet a given objective would vary from officer to officer.

THE MANAGEMENT OF REINFORCEMENT

Reinforcement according to an appropriate schedule and tied to the attainment of objectives (within a reasonable time) can be a valuable aid in motivating students. The two principal problems associated with reinforcement are identifying appropriate reinforcers and bringing them under the control of the instructional system.

Identifying Reinforcers. Several possible reinforcers have been mentioned. They, as well as others, will be listed here for emphasis. There are certainly others that could be identified. Two sources of ideas for reinforcers have been suggested—need satisfiers, and highly probable behavior. Specific reinforcers would include:

- (1) Rest periods and breaks.
- (2) Passes.
- (3) Knowledge of results.
- (4) Priority in the mess hall.
- (5) Freedom from disagreeable details.
- (6) Talking to other students.
- (7) Demonstrating one's proficiency to others and to oneself.

Controlling Reinforcement. Perhaps the main problem in providing reinforcers in a military training system is bringing reinforcement under the control of the training system. Frequently a separation exists between the instructional system and the agency responsible for the housing, feeding, and administration of the students. Many of the more significant reinforcers are under the control of the student company commander. To develop an effective method for management of students requires that these reinforcers be coordinated with the training

system. Then they will be delivered on the basis of achievement of the objectives and not on some other basis.

Unless this coordination takes place, it may be possible unknowingly to punish success or reward failure. For example, suppose that time off is being used as a reward. The student who receives the reward, and goes to his company area, may be put to work; in effect, he would be punished for being successful. Or suppose that failing students are given a considerable amount of free time and passes while awaiting orders to their next assignment. This would be rewarding failure, especially if students who are still in the course are comparatively restricted.

Polo C'deBaca¹ has successfully used reinforcement in several institutional settings and mentions practices that militate against effective use of reinforcers. He points out that it is common for the staffs unwittingly to reinforce undesirable behavior. They also give reinforcers away free, rather than making reinforcement contingent upon either meeting the desired training objectives or making effective progress toward those objectives.

SEQUENCE OF INSTRUCTION

The sequence of instruction can greatly affect the motivation of students. It can make the material more meaningful or less so. Any added meaningfulness makes content easier to learn.

Functional Context Sequencing

The preferred sequence of instruction follows the principle of Functional Context. This principle has been tested in a number of research studies, and has been shown to be capable of reducing failure, especially among students who are relatively low in aptitude (Brown et al., 123; Goffard et al., 124; Hitchcock, Mager, and Whipple, 125; Shoemaker, 126).

The essential idea of Functional Context sequencing is this:

- (1) The student is given a meaningful orientation to the entire job for which he is being trained.
- (2) Other topics are organized so that the relevance of each to the whole job can be demonstrated to the student at the time it is being taught.
- (3) A whole-to-part sequence is followed in teaching the functions of equipment.
- (4) Each student learns a graded series of job tasks. Each new task to be learned requires the student to master new knowledges and skills.

Thus, a context of the job is established. As the student learns new tasks, the tasks are related to the job context, and the knowledge and skill components are related to the task performance being learned.

A Less Meaningful Sequence

A less meaningful sequence is to begin the course with a block of "fundamentals." On analysis, these fundamentals usually turn out to be component knowledges and skills to task performance (1). Task performance is then taught later in the course.

Some typical examples of this practice are:

- (1) An introductory block on the use of hand tools required for later task performance.

¹Presentation at the 1966 meeting of the National Society for Programmed Instruction.

- (2) Blocks of mathematics, when later certain tasks require computation.
- (3) Theory of the operation of equipment (e.g., electronics and hydraulics) when later tasks call for troubleshooting and repair.

Taught in this order, these component knowledges and skills are taken out of the context of the tasks to which they are related. They are thus less meaningful and more difficult to learn. Students find difficulty in identifying the purpose of this "fundamentals" content.

Sometimes the fundamentals content is organized into a subcourse, which feeds several courses devoted to instruction in skills required for operation or maintenance of specific pieces of equipment. In addition to the problems caused by the lack of meaningfulness, these core courses tend to cover the maximum of fundamentals required by any single equipment-specific course. They thus tend to be longer than they need to be.

ASSURING CLASS ATTENDANCE

A certain amount of excused absence from class is unavoidable. At the same time, absences from the learning situation that are avoidable do occur. Students miss class because they are on details, and then have problems catching up to the rest of the class; they may miss a large part of the day's training because they went on sick call for a minor ailment.

Since a systems approach is being taken in this report, it should be stressed that situations that create unnecessary absences should be brought into coordination with the training system. For example, instead of students having to go to a specified location for sick call, using class time to walk or wait for transportation, it might be feasible to have a mobile dispensary visit the training area. Personnel and other specialists might also come to the training area.

Analysis of the reasons for excused absences may suggest a variety of ways to reduce impact of such absences on the training system. In one study (McCaslin, Woodruff, and Baker, 86), scheduling an entire platoon (or class) for detail during the same time period, instead of operating a duty roster of individuals, increased efficiency of training.

Chapter 6

AUTOMATION OF INSTRUCTION

AUTOMATION AND THE INSTRUCTIONAL SYSTEM

A Definition

Automation as applied to instruction became a topic of general discussion in the middle 1950s, when the teaching machine and programmed instruction were developed. In fact, one commonly used term for programmed instruction is automated instruction. Naturally, many teachers became concerned about unemployment resulting from technological advancement if automated instruction should become widespread. A certain amount of confusion in terms has led to disagreements and misunderstandings. At the same time, automated forms of instruction have continued to develop. The intention in this chapter is to clarify and refine various meanings of the concept of automated instruction, and describe some of the forms it has taken.

Automation in an instructional system refers to the performance of one or more functions of the system by a nonhuman component. By this definition, there is a considerable amount of automation in the typical classroom.

Two Extremes

A completely humanized (or nonautomated) teaching system—one in which all the functions (practice of performance, practice of knowledge, presentation of knowledge, management of students, and quality control) are performed by humans—is extremely rare. The typical classroom instructor uses many forms of automation; training aids include slides, training films, tape recorders, and television. Knowledge or performance may be practiced using workbooks and study guides. Tests are given on a mass basis, and often are scored by machine. However, all of these things are under the control of the instructor.

In a completely automated instructional system all system functions would be carried out by nonhuman components. The best example of this is the use of programmed instruction with no teacher present.

Advantages and Disadvantages of Automation

Automation carries a number of advantages. First, automated performance of system functions is invariable. For instance, a film shown over and over again will present the same information in the same way each time. By contrast, instructors differ in ability, and the same instructor will vary from time to time as he becomes bored, tired, ill, distracted by his personal problems, or especially inspired.

Second, completely automated instruction can provide effective training under conditions where instructor-centered classes are difficult to establish. If the students are dispersed, if qualified instructors are in short supply, if operational commitments make it difficult to assemble classes at a given

time—then automated "packages" of instructional materials may make it possible to conduct effective training despite these difficulties.

Probably the major disadvantage of automated methods is that they are more difficult to revise to meet changing training requirements than is the presentation by a live instructor.

Another problem is related to the present state of the art. It is not possible to automate the instruction for some objectives, especially those dealing with high levels of skill. This may be expected to change as the results of research show that more and more objectives may be attained through automated means.

Finally, automated methods may require more preparation time and effort than the nonautomated techniques. However, if the development costs can be applied against time and personnel savings when used with large numbers of students, automation can be more economical than instructor-based teaching.

PROGRAMED INSTRUCTION AND AUTOMATED INSTRUCTION

Development of Programed Instruction Concepts

Programed Instruction (PI) became significant in the middle 1950s. Originally, it referred to a method of instruction in which the teaching load was carried, not by an instructor, but by a specially prepared set of materials called a program. Programs generally had these characteristics:

- (1) The material to be learned was carefully sequenced and presented in small bits.
- (2) The student was continually active, answering questions and so solving problems.
- (3) The student received immediate knowledge as to whether his responses were correct.
- (4) The material was made easy for the student so as to guarantee a highly successful performance with few errors.

These characteristics were considered by many to be the integral features of this type of instruction; however, research has shown none of them is essential. Successful programs have been built, which violated each one of these presumably essential characteristics of PI.

As a number of aspects of the process of program development gradually became firm, a shift began to take place, so that PI was defined in terms of the process by which programs were prepared.

Program development includes the following steps:

- (1) A set of valid and clearly stated objectives is prepared.
- (2) A criterion test to measure achievement of the objectives is developed.
- (3) The content required to attain the objectives is embedded in appropriate media, applying appropriate principles of learning.
- (4) The program is tested and revised until the students achieve the objectives satisfactorily.

These steps describe in skeletal form the process for the development of an instructional system. They do not necessarily imply automation, if we assume that one of the possible media mentioned in Step 3 may be a human instructor. Thus, in a very general sense, the approach described in the series of reports by the present author can be termed PI.

There is no attempt in this report to deal extensively and specifically with PI. A number of references are listed for the convenience of the interested reader.

Automated Programed Instruction

The practice of using the terms programed instruction and automated instruction synonymously can be misleading. The practice evolved because the earlier PI efforts used teaching machines to present the programs. The PI programs may be presented in textbook form, as well as by teaching machines. However, human instructors may be part of PI.

Automated programed instruction refers to the performance of instructional functions by nonhuman means, but within the process of program development. That is, the media and content must be related to specific training objectives, and should be subjected to a criterion test to make sure that the materials actually do teach.

The teaching machine is typically used to present and practice knowledge. Machines are useful for a variety of special applications that require capabilities beyond those of the programed texts. For instance, if it is desired to show motion or sound, then a machine is necessary. Stolurow (127), however, has indicated his belief that the simple machine, which merely contains the program, will not hold its own against the programed text.

Automated Nonprogramed Instruction

The automation of various instructional functions takes many forms—training films, texts, and workbooks, for example. Historically, these items have not been programed in the sense defined above. They have not been developed to accomplish specific objectives, tested to determine whether they contribute to the achievement of objectives, or revised until they do. Considerable gain in increasing the effectiveness of these "traditional" training vehicles could be accomplished by including them under the concepts of programed instruction.

THE COMPUTER AND INSTRUCTIONAL SYSTEMS

The Possibility of Computer-Based Instruction

These days, the ultimate in automation is the computer. Limited use has been made of computers in the teaching process. These uses have been experimental, but more and more can be expected from this versatile device.

Stolurow (81) discusses the role of the computer in instruction and presents ten critical requirements for a teaching machine. His discussion provides a framework for considering the possible use of a computer-based instructional system. His critical requirements are summarized here:

(1) Display (Presentation). The material to be learned is presented to the student by a display unit. A variety of communication channels—sight, sound, touch, or a combination of these—may be used. In certain kinds of courses, information may be followed by a question to answer or a problem to solve. In other situations complex skills, such as flying an aircraft, may require that the student have faithful representations of significant environmental conditions. The display unit should present both information and knowledge of results to the student.

(2) Response. A component is required to enter the student's response or action into the teaching machine. The nature of the response component will depend on the kind of response the student is to make.

(3) Pacing. The pacing unit is a timing device that can vary the time intervals between the question and the answer, or between one question and another. Or it may vary the speed of the presentation.

(4) Comparator. The comparator analyzes the student's response by comparing it with the correct response stored in the teaching machine. The pacer unit may affect the comparator when the time of response is a significant aspect of the training objective.

(5) Knowledge of Results. The correctness or incorrectness of his response must be communicated to the student. In some instances this is a simple matter of permitting the student to compare his response with the correct one. In others, the teaching machine may provide special signals, or additional instruction in the case of a wrong response.

(6) Collator-Recorder. This component measures and records the learning process. Either a collator or a recorder will collect appropriate data, such as the number of errors, types of errors, and time required for a response. The recorder simply accumulates data; the collator relates the data to the program.

(7) Selector. The selector chooses the next item in the program for presentation to the student. The item selected may depend on the student's aptitude and previous learning record, thus permitting the teaching machine to adapt to the student's requirements.

(8) Library. The library unit stores information that can be released to the student as he needs it. It may vary in capacity, access time, and the form of storage. The access time of knowledge of results is especially important.

(9) Programing. A sequence of items is required, whether predetermined or in a sequence that adjusts to the learner's progress. The programing unit determines the sequence of learning activities.

(10) Computer. The computer is almost a necessity if the teaching machine system is to be highly versatile. It can provide, depending on the particular training objective, all or many of the foregoing requirements.

Thus the computer can be viewed as a versatile tool. Whether it should be used in a particular setting should depend on a cost-effectiveness analysis.

An Example of Computer-Based Instruction

Most of the experimental uses of computer-based instruction, of which there have been a number, are described by Coulson (128). The experimental CLASS system of the System Development Corporation provides an example of how a computer-based system operates.

Imagine, if you will, a room with 20 student stations and an instructor station. The student station consists of a table on which are a film viewer, tape recorder, and sometimes a book. There is also a multiple-choice response device, which provides knowledge of results to the student after his response, in the form of signals that can indicate right, wrong, or the correct answer. With the response device the student can request a review or call the teacher for assistance.

The computer controls the program, records student progress, and adjusts the program to the student. It evaluates the student's response and determines what the student should do next, depending on the rules of a given experiment. The computer records the particular error made by the student and the error rate. It also records the speed of response. Slow responding may indicate reading difficulty, in which case the student may be directed to an easier or more pictorial program.

The teacher can monitor any student's work from a control panel. If the instructor wishes to help a student, he can. The student may call for help from the teacher. So may the computer, if a student is making too many errors but hasn't called the teacher.

When the instructor is called, he can obtain data on the student's progress that will help him to diagnose the student's difficulties. From the teacher's station, the various audio-visual devices can be controlled.

In this system, a number of the critical requirements described by Stolurow can be identified. There are displays, response devices, a comparator, knowledge of results, a collator, a selector, a library, a variety of programs, all tied into, or part of, a computer.

Computer-Based Information Systems

Computers can be used in schools for purposes other than instruction. Various applications of computers in the development of school information systems are described by Bushnell (129). Computers have also been used for scheduling courses to optimize the use of facilities, for assigning students to classes, and for designing efficient school bus routes.

Relevant to the management of students function, Egbert and Cogswell (130) describe the design of a Surveillance and Detection System for a school built to operate on a continuous progress plan. This system automatically monitors inputs describing student performance, detects trouble, and determines the persons to be alerted in case of trouble.

Computer Models of Instructional Systems

Another use of computers is to analyze models that simulate instructional systems. A model of a school system can be developed that frequently provides a number of advantages over observation and study of the actual system, assuming reasonable fidelity can be obtained.

When a system is too large and complex for observation, simulation permits study of the system without interruption of ongoing activities. Time periods may be expanded or compressed. The operation of the system over a period of years can be simulated in a few minutes in order to study long-term trends. Or processes may be slowed down for detailed study.

For training, simulation can show the trainee or the decision maker the advantages and disadvantages of different procedures. The learner can have fairly immediate knowledge of the results of his actions. Training in the environment of a simulated whole system prevents piecemeal learning of the operation of the system.

If a new system is being designed, or changes are being introduced into an existing system, simulation can facilitate evaluation of the effects of the change.

The several references by Bushnell, Cogswell, Egbert, and associates describe a number of features of computer simulation of school systems.

Part II

**A GUIDE TO THE DESIGN AND
EVALUATION OF INSTRUCTIONAL SYSTEMS**

Chapter 7

THE GENERAL SYSTEM PLAN

It is suggested that the initial stage in the design of the instructional system be the development of a General System Plan. This plan should identify the major outlines of the system, including the following:

- (1) Constraints
- (2) Sequence of Objectives
- (3) Management of Students
- (4) Quality Control

CONSTRAINTS

The plan should identify the constraints that limit the choices of the system designer. The following outline lists factors to be considered. Under each heading the implications of each factor in terms of constraints should be indicated.

Constraints

- A. Overall Length of Course
- B. Nature of Student Input
 1. TDY or PCS
 2. Average aptitude
 3. Range of aptitude
 4. Previous experience
 5. Projected student load
- C. Related Systems
 1. Student support and administration
 2. Supply
 3. Maintenance
- D. Cost Ceilings
- E. Personnel Ceilings
- F. Policies
- G. Other Constraints

THE SEQUENCE OF OBJECTIVES

The Functional Context Principle

The sequence in which objectives will be taught is another aspect of the General System Plan. The order of the objectives should follow the functional context principle as discussed in Chapter 5. It will be recalled that the sequence starts with an orientation of the student to the job as a whole. The relation of each learning activity to the total job is emphasized. The student learns a series of graded job tasks, each requiring him to learn new knowledges and skills to master the task. Finally, major pieces of equipment are taught in a whole-to-part-sequence, with the function of the whole equipment serving as a

context for learning the function of each major component, and so on down to the parts.

If the system designer can apply the functional context principle on the basis of this guidance and that contained in the appropriate references to Chapter 5, well and good. If not, the procedure to be described will provide an objective way of sequencing the objectives to achieve a close approximation to functional context sequencing.

A Technique for Functional Context Sequencing

The first item in the course should be an orientation of the student to the entire job for which he is being trained. This can be done in a number of ways: maintenance personnel can be taught how to operate equipment; work areas can be toured, with explanations of the duties to be performed, and the major items of equipment used; training films, kinescopes, or television can be used to present overview materials.

The remainder of the topics will be placed in an order based on the following principles:

- (1) The duties of the job will be taught one at a time, since the tasks to be performed under a particular duty are related to each other.
- (2) It is important to have the student practice the performance of tasks as early as possible.
- (3) Component skills and knowledges, once mastered in one task, should be used quickly in another task, so that the student can review and practice them. Such a procedure will favor overlearning.

The Index of Task Complexity

The need for a hierarchy, or organization chart, of the component knowledges and skills for each task was pointed out in the report on objectives (1). A simple task has few levels of components and few components for each level, while a complex task has many levels and many components at each level.

An Index of Complexity that will indicate the number and level of component skills and knowledges can be computed for each task (Figure 2). Since it is quite possible that different analysts might define the same job behavior as

Index of Complexity

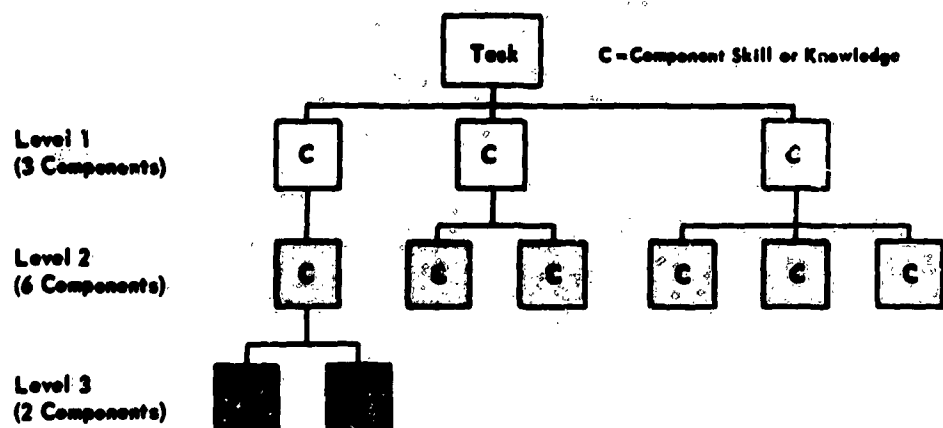


Figure 2

one broad task or a series of narrower ones, the index should not be considered as absolute. The technique is offered as a suggestion for making a tentative order out of the total requirements of the job.

The Index of Complexity is computed by multiplying the level (L) by the number of components (C) at that level, and adding these products. In Figure 2, then, there are three first-level components; the product of L and C is 3. There are six second-level components; the product of L and C is 12. There are two third-level components; the product of L and C is 6. The sum of all these products is 21. This task, therefore, has a complexity index of 21.

A task of low complexity has a small number of component skills and knowledges that must be mastered before the whole task performance can be practiced. Since the student ought to practice performance as early as possible, it is desirable to have tasks of low complexity taught first. However, tasks must be considered in relation to the duty of which they are a part. In order to preserve meaningfulness in relation to the job, all the tasks within a single duty should be taught as a unit.

Thus, speaking in a general way, it can be said that the first duty to be taught should be that with the lowest average Index of Complexity for its composite tasks; similarly, the first task to be taught should be the one with the lowest Index of Complexity.

The Reduced Index of Complexity

The first task has been selected. How is the next to be selected?

The other tasks in that duty will probably have some components that are identical to those of the first task. Similarly, some tasks in other duties may have identical components. There is no point in teaching these identical components over and over again. Therefore, in sequencing teaching, it will be necessary to identify these repeated components, and recompute the original Index of Complexity (ICo) for each task, leaving out the repeated components. This procedure will yield a Reduced Index of Complexity (ICr).

At this point, an ICr has been obtained for every task in the first duty except the first selected. It would seem reasonable to select the task with the lowest ICr to be next. However, there is a further matter to consider. In selecting tasks to be taught next, it is desirable to choose those containing knowledge or skill components that have already been taught. This will permit further practice soon after original teaching, lessening the likelihood that the student will forget the component.

Accordingly, the difference between the ICo and ICr is used to take this factor into account. This difference is subtracted from the ICr, to yield an Effective Index of Complexity (ICe).

To summarize:

$$ICe = ICr - (ICo - ICr) \text{ or } ICe = 8 - (10 - 8) = 6$$

$$ICe = 2(ICr) - ICo \text{ or } ICe = 2(8) - 10 = 6$$

The Effective Index of Complexity is used to sequentially select all tasks in a duty in order of smallest (least positive or most negative) ICe value.

A Summary of Functional Context Sequencing

A rationale and an objective procedure for developing approximations to functional context sequences have been presented. The procedural steps for sequencing a whole job may be summarized as follows:

- (1) Compute ICo for all tasks.
- (2) Compute mean ICo for the tasks in each duty.

- (3) Select as first duty to be taught the duty with the lowest mean ICo.
- (4) Select as first task in that duty to be taught the task with the lowest ICo.
- (5) Eliminate from all remaining tasks in that duty the components shared with the first task, that is, compute ICr for the remaining tasks.
- (6) Compute $ICe = 2(ICr) - ICo$ for all tasks except the first in the first duty.
- (7) Select the task with the smallest ICo as the next task to be taught.
- (8) Repeat Steps (5) through (7) until all tasks of the first duty are arranged in sequence.
- (9) Compute mean ICo for remaining duties.
- (10) Select as the next duty to be taught the duty with the smallest mean ICo, and repeat Steps (4) through (8).
- (11) Repeat the cycle until all duties are sequenced.

Admittedly, this is a laborious procedure if performed by hand. With proper coding and identification of components, it could be performed by a computer.

The Sequence of Objectives for the General System Plan

For the purposes of the General System Plan, it is sufficient to list the orientation to the job, and the tasks to be taught. The identification of repeated components—done in the Functional Context sequencing—should be retained for later use in analyzing the requirements for training equipment, personnel and material, and for designing lessons.

MANAGEMENT OF STUDENTS

The General System Plan should identify the major features of the student management function. (The material in Chapter 5 should be used as a guide.) The following outline of topics may serve as a suggested list of matters to describe:

- A. Methods for Adjusting to Individual Differences
- B. Reinforcement
 1. Types of reinforcement available
 2. Agency presently controlling each type
- C. Controls Over Student Absences

QUALITY CONTROL

The essential elements of the quality control function have been described in a previous report (2). These are:

- (1) Tests on both task and component objectives.
- (2) A method for feedback of results of tests to instructional system managers.
- (3) Procedures for taking appropriate action on the results.
- (4) Supervisory support.

It has been assumed that tests have been prepared, or will be prepared early in the process of system development. For the General System Plan, a brief

description of method by which each of the four essential elements of the quality control system will be accomplished will be sufficient.

THE NATURE OF THE GENERAL SYSTEM PLAN

The purpose of the General System Plan is to provide an overall framework for later development, so that people who are working on specific aspects of system development will have the same overall view of the major aspects of the system.

The plan should be considered tentative and subject to change, should the later, more detailed work make it advisable.

Chapter 8

DESIGN OF THE LESSON

The term lesson as used here means all the activities necessary to accomplish a given task-level training objective. The design of the lesson is described in this chapter. Topics discussed include identification of system functions appropriate for specific objectives, selection of system components to accomplish these functions, specifications of the lesson, the preliminary test of the lesson, and development of the lesson plan.

IDENTIFICATION OF SYSTEM FUNCTIONS

The first step in lesson design is to identify the functions that must be accomplished to attain the objective.

Guidelines for Arranging System Functions

Guidelines for arranging system functions include the following:

- (1) The initial activity in teaching a job is to orient the trainee to the job. This may be done primarily by presentation.
- (2) The initial activity in teaching a new duty is an orientation to the duty, relating the duty to the job, and describing briefly the tasks of that duty. This, too, may be done primarily by presentation.
- (3) The initial activity in teaching a task is to provide a demonstration of the performance of the task, and to identify the component knowledges and skills required.
- (4) If a task is of low complexity, with an initial or reduced index of 7 or less, get the students to practice immediately after the demonstration.
- (5) If a task is of greater complexity, use the functional context method as described in Chapter 7 as a guide to sequencing the organization of the objectives.
 - (a) Select one of the first-level components (see Figure 2).
 - (b) Teach that component, but starting from its lowest level, and proceeding upward.
 - (c) Repeat for all other first-level components.
- (6) As a tentative guideline, assume that once a component has been taught, it need not be retaught to mastery. Only a reminder by presentation will be necessary. This will not be true in some instances, but the methods of testing the lesson to be described later in this chapter will detect those instances in which review will be necessary.
- (7) Generally, the final, or next to final, function will be that of quality control, in which the student demonstrates his attainment of the task objective.
- (8) In the initial tasks of the total sequence the final function in each task will be reinforcement, for about ten tasks. Then reinforcement should be reduced gradually until a ratio of one reinforcement to every five tasks reached. In assigning the reinforcement, avoid consistent patterns during any ratio. For example, if the ratio is one reinforcement to every three tasks, do

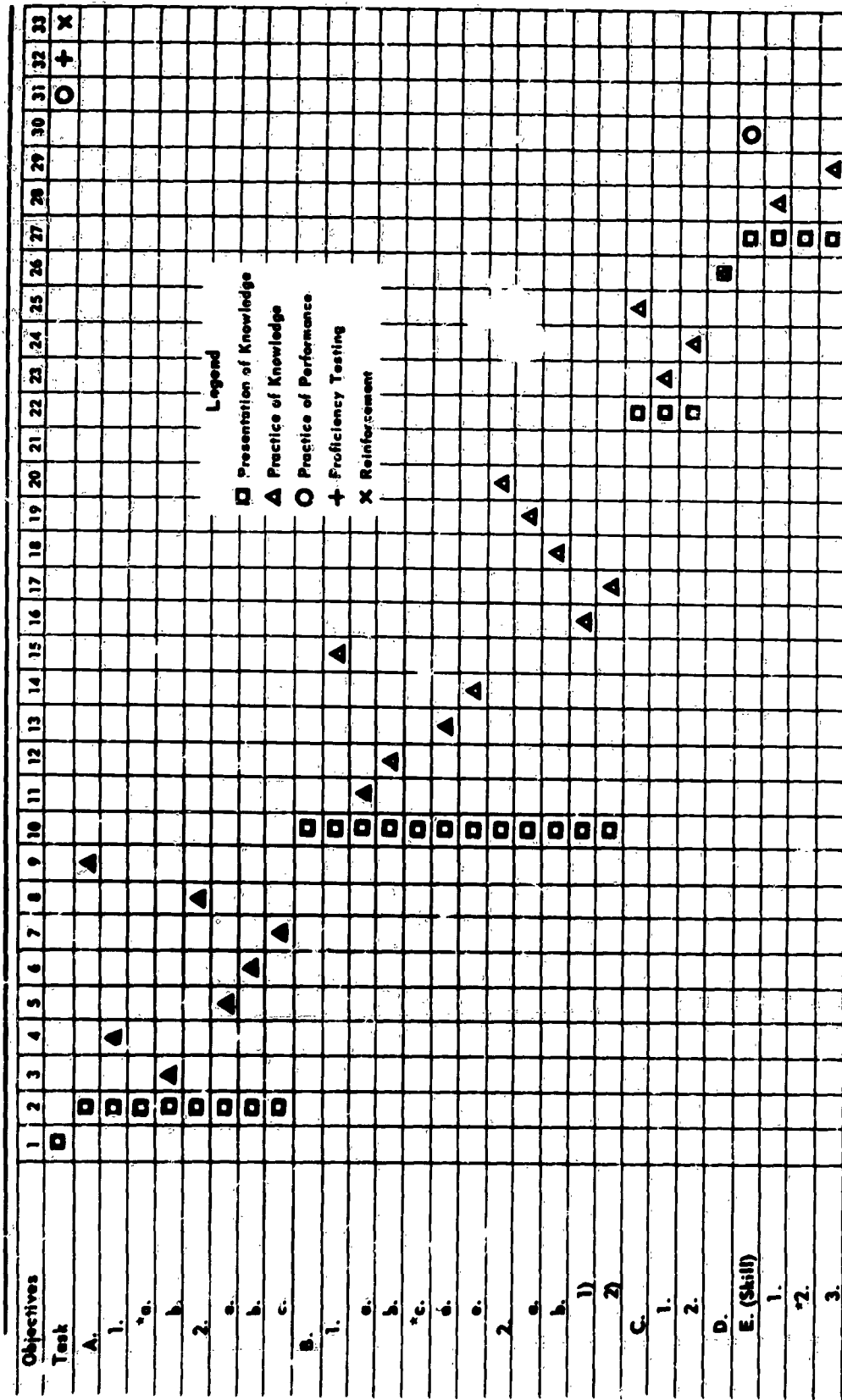
(10) The orientation or "bridge" content described in the first three guidelines need not be practiced.

An example of a Lesson Function Chart for a simple task is shown in Figure 3. In this task, the function chart indicates a presentation in the first

[illegible]

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Lesson Function Chart: A Complex Task



*Indicates objectives have been previously taught and will not be repeated, but are required for this particular task.

Figure 4

phase, covering the task and all its components. Then the total task is practiced, the student's proficiency is graded, and if successful, he receives a reinforcer.

An Illustration of a Complex Task

A Lesson Function Chart for a more complex task is shown in Figure 4. In Phase 1 there is a presentation symbol, representing an orientation to the task and a demonstration, illustrating Guideline (3). In Phase 2 the possibility of a coherent, reasonably short presentation covering all subcomponents of Component A is recognized. Phase 3 begins the sequence of practice for Component A, following Guideline (5).

There is no practice of knowledge for Component A.1.a.; the asterisk indicates it has been taught before. However, it has been included in the presentation of Phase 2 to remind the students.

Phases 10, 23, and 27 are similar to Phase 2, but for other major components.

Phase 26 represents a merger of presentation and practice of knowledge for Component D, which is not a complex major component.

Phase 30 represents the practice of skill performance for Component E.

Phases 31, 32, and 33 represent practice of the whole task, proficiency testing, and reinforcement, illustrating Guidelines (7), (8), and (9).

The points illustrated in the examples should not be thought of as rigid rules. The nature of the organization of the objectives may suggest other ways of combining presentation and practice that will better preserve the natural organization and meaningfulness of the objectives.

The principal value of the Lesson Function Chart is to lay out the functions required by a lesson in an appropriate sequence prior to specifying ways of accomplishing these functions. Later developmental work may make it necessary to introduce changes.

SELECTION OF SYSTEM METHODS AND COMPONENTS

General Guidelines for Accomplishing Functions

Once the functions have been identified in a Lesson Function Chart, methods and materials are selected for the accomplishment of each function. Part I has described each of the functions and indicated ways to accomplish them effectively. There are usually a variety of possibly effective methods—some automated and some not, some suitable for large classes, some for small classes, and so forth—depending on the system constraints.

The several effective ways of accomplishing a given function will differ in cost. In general, select the least costly way. Cost and effectiveness are discussed in Chapter 9, which provides more detailed guidelines for cost considerations.

Practice of Performance

Selecting an Effective Method

The essential requirements for an effective method for practicing performance are an adequate simulation of the task or skill—based on the detailed task description—and a method for providing KOR. Other factors include the practice schedule, verbalization, and pacing.

The principal possibilities that should be considered are:

- (1) How should the task be simulated?
 - (a) With actual equipment, terrain, etc.

- (b) With obsolete equipment.
- (c) With training devices.
 - 1 With a whole task simulator.
 - 2 With a series of part-task simulators.
- (2) How will the correctness of the student response be determined?
- (3) How will KOR be provided?
 - (a) Automatically.
 - (b) By instructor.
 - (c) By other students.
- (4) Can practice be automated?

The choices described above should generate several possible practice methods, which should be described briefly and then analyzed for costs.

Cost Considerations

The cost of each method should be estimated. Among the kinds of costs to be considered are:

- (1) Development and procurement, or construction
- (2) Expendable supplies
- (3) Replacement and maintenance
- (4) Spare parts
- (5) Personnel costs
- (6) Storage

Once assured that the methods and components are effective, determine the cost per student as a basis for selecting a method.

Practice of Knowledge

Selecting an Effective Method

The essential requirements for a method for practicing knowledge are:

- (1) A method for presenting a symbolic cue to the student.
- (2) A method for judging whether the student's response is correct.
- (3) A method for delivering KOR to the student.

The principal choices for the practice of knowledge will include:

- (1) Self-Instructional Methods
 - (a) Programed learning
 - 1 Programed texts
 - 2 Teaching machines, with appropriate programs
 - (b) Workbooks, with answers provided
 - (c) Flash cards, etc.
- (2) Classroom Feedback Methods
- (3) Student-Coach Methods

Cost Factors

Cost factors here are similar to those for practice of performance:

- (1) Development and procurement
- (2) Expendable supplies
- (3) Replacement and maintenance
- (4) Spare parts
- (5) Personnel costs
- (6) Storage

Again, the selection of an effective method should be based upon the lowest cost per student.

Presentation of Knowledge

As long as the presentation is meaningful, is properly spaced for effective communication, and can be accurately received by the student, there is little difference in effectiveness between one medium and the other.

Singly or in combination, the choices include:

- (1) Lectures or demonstrations by live instructors
- (2) Films
- (3) Television
- (4) Tape recordings
- (5) Books and other written material
- (6) Training aids

Again, the selection should be made on the basis of the cost per student.

Proficiency Measurement

At the conclusion of the practice of each task, the student should be required to demonstrate his proficiency in one of two ways. The first choice is to observe the student and score each trial in the practice session. Then, when the student reaches the objective, pass him. The second choice is to have a separate proficiency test. Procedures for developing accurate proficiency measures are described in the quality control report (2).

The costs for each choice depend on requirements for test administrators and scorers, special equipment or test devices, and the possibility of automation.

Reinforcement

The General System Plan, described in Chapter 7, will, when developed, contain a list of feasible reinforcers. The choice of reinforcers may be based on such factors as cost, administrative feasibility, and ease of application.

LESSON SPECIFICATION

After the various choices have been made as to methods for accomplishing the functions, the results should be entered into a Lesson Specification. This is the basic blueprint for the actual construction of the lesson. It will serve as a guide to requirements for personnel, equipment, and supplies. It will indicate all the devices needed for practice and presentation of skills and knowledge.

No particular format will be prescribed. However, the following suggestions are made as to the content of the Lesson Specification:

- (1) Key the organization of the specification to a Lesson Function Chart. Indicate exactly how each function for each objective will be carried out, by phases.
- (2) Include an estimate of the number of trials, or the amount of time required for each function for each objective.
- (3) Make a special effort to identify exactly what the instructor, if any, will be doing at each phase.
- (4) For each practice phase, whether of performance or knowledge, indicate the requirement for instructions on how to practice.
- (5) Indicate any references deemed necessary for use as a guide to good practice by those who are constructing the lesson.
- (6) Indicate whether a particular item is already available or must be developed or procured.

PRELIMINARY TEST OF THE LESSON

After the lesson has been constructed, it is very desirable to give it a preliminary test. It should be administered in accordance with the Lesson Specification. Following the lesson, the students should take a test covering the task-level and all component-level objectives. If a satisfactory number of students meet the task-level objectives, the lesson is acceptable. If not, examination of the test items dealing with component-level objectives will help pinpoint specific problems.

During the preliminary test, it is also desirable to determine the answers to these questions:

(1) Were there any points at which students were confused and did not know what to do? This may suggest revision of the instructions, or the addition of new ones.

(2) Were there any periods during which the instructor, if any, was overloaded, with so much to observe or do that he could not perform his duties effectively? If so, the load should be lightened.

(3) Were there any periods during which the students' attention wandered? This may suggest the need for more attention to making the content interesting.

(4) Was much student time spent in getting ready to practice? This may suggest the need for preplacement of practice materials.

(5) Was fatigue evident at any part of the lesson? This may suggest the need for a rest period.

If substantial numbers of students fail to perform the task even though they pass the component tests, examination of the need for more task practice is suggested. Measuring proficiency on each trial will indicate whether more practice than that required by the present lesson is necessary.

If, in addition to failing the task-level test, one or more components are also failed by a substantial proportion of students, additional practice of the components is suggested. Again, analysis of the amount learned after each trial will indicate the amount of component practice needed.

If the instructional system being developed is to replace an existing course, it may be tested a lesson at a time by obtaining students who meet the prerequisites. On the other hand, if the system does not replace an existing course, it may be given a preliminary test during the first class of students going through the system.

THE LESSON PLAN

After any revisions necessitated by the preliminary test have been made, a lesson plan should be prepared. The lesson plan should include the following information:

- (1) The objectives of the lesson.
- (2) The material and supplies needed.
- (3) A complete description of all activities, in sequence, including proficiency measurement and any reinforcers to be provided the student.

Chapter 9

EVALUATION OF THE SYSTEM

Evaluation of the system begins with the preliminary test, discussed in the previous chapter, and continues through the life of the system. Why the need for continuous evaluation?

First, the system will change, as a result of many factors. Personnel will change, and as they do, the new people will change various aspects of the system. The changes may be for the good, or they may not. It is important to know the effect of these changes.

Second, it may not be possible to make all the adjustments required by the results of the preliminary test before the system is put into operation. The system may require further improvement and refinement after it is operational.

Third, new techniques will be developed that may make the system more efficient. These techniques will have to be evaluated.

Finally, it is practically impossible to keep the system functioning exactly as it was designed. Changes, planned or unplanned, will occur. The effectiveness of the system can slowly diminish unless evaluation is continuous.

MEASURING THE EFFECTIVENESS OF THE SYSTEM

Overall System Effectiveness

Techniques for measuring overall effectiveness of the system are included in the quality control function, and have been described in the quality control report (2). Essentially, the method calls for development of tests of the task-level objectives. When these are administered to the students, the results indicate the effectiveness of the system in developing task performance. The appropriate overall measure of system effectiveness is the proportion of objectives successfully attained by the students, or:

$$\frac{A}{BC}$$

in which:

A is the total number of objectives attained, for all students

B is the total number of objectives measured by the test

C is the total number of students

The Effectiveness of the Lesson

A measure of effectiveness of the total lesson can be developed in a manner comparable to that of the total system. Here, however, since there is only one task-level objective, the number of objectives attained is divided by the number of students or:

$$\frac{A}{C}$$

in which A and C are defined as above.

Effectiveness of Lesson Functions

If the lesson's overall effectiveness has been shown to be less than is desirable, how can the difficulty be pinpointed?

Each function of the lesson—practice of performance and presentation and practice of knowledge—has been designed to produce a student who has attained an objective, either at the task or the component level. By testing students on all of the components of the task, it is possible to determine more exactly where the problem is.

If one or more component objectives are not being taught, it is appropriate to examine those functions designed to teach them. Nearly every presentation and each practice session should bring some progress. The contribution of each can be determined by testing different groups of students before and after each activity designed to accomplish that objective.

COMMON SYSTEM FAULTS

The purpose of this section is to identify a number of reasonably typical system faults, as an aid in correcting system deficiencies. It may be used as a check list by persons concerned with the evaluation and improvement of instructional systems. In addition, the appendix contains a more comprehensive check list.

Inconsistency With Objectives. The various functions as actually put into practice may not reflect the requirements of the objectives. Students may not be practicing the appropriate skills and knowledge. Tests used to measure achievement may not be proper indicators of the attainment of the objectives. Even the presentations designed solely to increase meaningfulness may be tested as if they were specific to course objectives.

Inadequate Consideration of Individual Differences. Students of widely varying aptitudes and experience may be required to undergo identical activity during training.

Poor Coordination. It may be that, because of lack of coordination, all aspects of the system are not working together. Instructors may disagree with their assigned role in the system. Parts of courses may be taught by different departments, which may vary in approach and effectiveness. And the student support agency may differ with the school.

One way of analyzing the total system is to diagram the flow of information through it. The methods are described in detail by Churchman, Ackoff, and Arnoff (131).

Lesson Difficulties. A number of difficulties may occur within the lesson. Among these are:

- (1) Lack of meaningfulness.
- (2) Lengthy sessions of presentation and student activity.
- (3) Little or no knowledge of results.
- (4) Lack of, or ineffective, reinforcement.
- (5) Instructor overload because of too many activities occurring in the classroom at once.
- (6) Confusion resulting from poor instructions to the students as to how to practice.

COST AND EFFECTIVENESS

The manager of the instructional system will be concerned not only with the effectiveness of the system, but with its cost as well.

A Cost-Effectiveness Ratio for Training

The measure of efficiency suggested is that of cost per objective attained per student. This measure will reflect costs, the effectiveness of training, and the number of students, and will vary as these factors vary.

Examples of Cost

A matter of considerable importance to the system manager should be the development of an accurate cost-accounting system. Among the costs of system operation would be:

- (1) Student salaries, allowances, and other costs while attending school.
- (2) Instructor, supervisor, and student support salaries.
- (3) Cost of equipment procurement and maintenance.
- (4) Expendable supplies.

In some cases, especially where automation is being considered, student travel would be a relevant cost. It may be more economical to ship an automated training package to the student than to bring the student to the school.

Among the costs of development would be salaries and allowances of all personnel involved in planning, developing, and testing the system.

Analyses of Cost-Effectiveness Data

With appropriate cost-effectiveness data, a number of possibilities arise for identifying ways of improving the efficiency of training.

Efficiency may be raised by lowering costs or by increasing the number of students attaining the objectives. Separation of the elements entering into the cost-effectiveness ratio may suggest ways of increasing the effectiveness of training. If, however, the effectiveness is already high, special attention should be paid to costs. Even though the cost of attaining various objectives will legitimately vary from objective to objective, comparisons of the costs of various lessons will be an appropriate starting point for explaining why variation exists. Perhaps some lessons need cost reduction.

Analysis of different kinds of costs may also reveal particular areas in which cost-reduction efforts may be especially fruitful. In some instances, for example, the cost of equipment operation is a major expense. With appropriate design of training devices for transfer, it may be possible to reduce the amount of equipment operation required, and thus reduce costs.

Cost-effectiveness analyses, in principle at least, show promise of being a significant factor in increasing the efficiency of instructional systems.

**SELECTED BIBLIOGRAPHY
AND
APPENDIX**

SELECTED BIBLIOGRAPHY¹

Chapter 1

What an Instructional System Is

1. Smith, Robert G., Jr. *The Development of Training Objectives*, HumRRO Research Bulletin 11, June 1964.
2. Smith, Robert G., Jr. *Controlling the Quality of Training*, HumRRO Technical Report 65-6, June 1965.

Additional References

- Churchman, C.W., Ackoff, R.L., and Arnoff, E.L. *Introduction to Operations Research*, John Wiley & Sons, Inc., New York, 1957.
- Flagle, Charles D., Huggins, William H., and Roy, Robert H. (eds.). *Operations Research and Systems Engineering*, Johns Hopkins Press, Baltimore, 1960.
- Gagné, Robert M. (ed.). *Psychological Principles in System Development*, Holt, Rinehart and Winston, Inc., New York, 1962.
- Goode, H.H., and Machol, R.E. *System Engineering*, McGraw-Hill Book Co., Inc., New York, 1957.
- Porter, E.H. *The System Thinkers: Parable and Paradigm*, SP-285, System Development Corporation, Santa Monica, 1961.
- Stolurow, Lawrence M. *Some Educational Problems and Prospects of a Systems Approach to Instruction*, Technical Report No. 2, Training Research Laboratory, University of Illinois, Urbana, March 1964.

Chapter 2

The Practice of Performance

- (1) Smith, Robert G., Jr. *The Development of Training Objectives*, HumRRO Research Bulletin 11, June 1964.
3. Bilodeau, Edward A. *Some Effects of Various Degrees of Supplemental Information Given at Two Levels of Practice Upon the Acquisition of a Complex Motor Skill*, Research Bulletin 52-15, Perceptual and Motor Skills Laboratory, Human Resources Research Center, Lackland AFB, Tex., April 1952.
4. Bilodeau, Edward A., Bilodeau, Ina McD., and Schumsky, Donald A. "Some Effects of Introducing and Withdrawing Knowledge of Results Early and Late in Practice," *J. Exp. Psychol.*, vol. 58, no. 2, August 1959, pp. 142-144.

¹In order to provide a complete list of references for a particular topic, as well as for the report as a whole, the references are grouped by chapters. In each chapter they are listed in the order they are mentioned in that chapter. Citations repeated in subsequent chapters are listed with their original citation number in parentheses. Additional references, uncited but of relevancy and interest to the reader, are listed at the end of the numbered citations for each chapter. Those additional references with numbers in parentheses have been cited in previous chapters.

5. Goldstein, Mymon, and Rittenhouse, Carl H. "Knowledge of Results in the Acquisition and Transfer of a Gunnery Skill," *J. Exp. Psychol.*, vol. 48, no. 3, September 1954, pp. 187-196.
6. Kinkade, R.G. *A Differential Influence of Augmented Feedback on Learning and on Performance*, Technical Report TDR-63-12, Aerospace Medical Research Laboratories, Wright Air Development Center, Wright-Patterson AFB, Ohio, February 1963 (Contractor: Ohio State University).
7. Miller, Robert B. *Psychological Considerations in the Design of Training Equipment*, Technical Report 54-563, Wright Air Development Center, Wright-Patterson AFB, Ohio, December 1954 (Contractor: American Institute for Research).
8. Ammons, Robert B. *Knowledge of Performance; Survey of Literature, Some Possible Applications, and Suggested Experimentation*, Technical Report 54-14, Wright Air Development Center, Wright-Patterson AFB, Ohio, February 1954.
9. Bilodeau, Edward A., and Bilodeau, Ina McD. "Variation of Temporal Intervals Among Critical Events in Five Studies of Knowledge of Results," *J. Exp. Psychol.*, vol. 55, no. 6, June 1958, pp. 603-612.
10. Bilodeau, Edward A. *Transfer of Training After Part Practice on a Dual-Control Tracking Apparatus*, Research Report 56-110, Operator Laboratory, Air Force Personnel and Training Research Center, Randolph AFB, Tex., September 1956.
11. North, Alvin J., and Harrington, James, Jr. "Learning Response Compounds Having Two Critical Components," *J. Exp. Psychol.*, vol. 47, no. 3, 1954, pp. 173-178.
12. Seymour, W. Douglas. "Experiments on the Acquisition of Industrial Skills. Part III," *Occup. Psychol.*, vol. 30, 1956, pp. 94-104.
13. Adams, Jack A., and Hufford, Lyle E. "Contributions of a Part-Task Trainer to the Learning and Relearning of a Time-Shared Flight Maneuver," *Human Factors*, vol. 4, no. 3, June 1962, pp. 159-170.
14. Briggs, George E., and Naylor, James C. "The Relative Efficiency of Several Training Methods as a Function of Transfer Task Complexity," *J. Exp. Psychol.*, vol. 64, no. 5, November 1962, pp. 505-512.
15. Dougherty, Dora J., Houston, Robert C., and Nicklas, Douglass R. *Transfer of Training in Flight Procedures From Selected Ground Training Devices to the Aircraft*, Technical Report 71-16-16, U.S. Naval Training Device Center, Port Washington, N.Y., September 1957 (Contractor: University of Illinois).
16. Briggs, George E., and Waters, Lawrence K. "Training and Transfer as a Function of Component Interaction," *J. Exp. Psychol.*, vol. 56, no. 6, December 1958, pp. 492-500.
17. Adams, Jack A., and Reynolds, Bradley. "Effect of Shift in Distribution of Practice Conditions Following Interpolated Rest," *J. Exp. Psychol.*, vol. 47, no. 1, 1954, pp. 32-36.
18. Norris, Eugenia B. "Performance of a Motor Task as a Function of Interpolation of Varying Lengths of Rest at Different Points in Acquisition," *J. Exp. Psychol.*, vol. 45, no. 4, 1953, pp. 260-264.
19. Reynolds, Bradley, and Bilodeau, Ina McD. "Acquisition and Retention of Three Psychomotor Tests as a Function of Distribution of Practice During Acquisition," *J. Exp. Psychol.*, vol. 44, no. 1, 1952, pp. 19-26.
20. Esper, Erwin A., and Lovaas, O. Ivar. "The Effect of Verbal Symbolization on the Serial Position Curve in Motor Perceptual Maze Learning," *J. Gen. Psychol.*, vol. 66, First Half, January 1962, pp. 47-51.
21. Gagné, Robert M., and Smith, Ernest C., Jr. "A Study of the Effects of Verbalization on Problem Solving," *J. Exp. Psychol.*, vol. 63, no. 1, 1962, pp. 12-18.

22. Neumann, Eva. "Frequency and Usefulness of Verbal and Nonverbal Methods in the Learning and Transfer of a Paired-Associate Serial Motor Task," *J. Exp. Psychol.*, vol. 60, no. 2, August 1960, pp. 103-110.
23. Ray, Wilbert S. "Verbal Compared With Manipulative Solution of an Apparatus-Problem," *Amer. J. Psychol.*, vol. 70, 1957, pp. 289-290.
24. Woolman, Myron. *On-Site Training of Guided Missile Operators*, HumRRO Technical Report 64, August 1960.
25. Adams, Jack A. "The Effect of Pacing on the Learning of a Psychomotor Response," *J. Exp. Psychol.*, vol. 47, no. 2, 1954, pp. 101-105.
26. Anderson, Norman H., Kresse, Frederick H., and Grant, David A. "Effect of Rate of Automatically-Paced Training in a Multidimensional Psychomotor Task," *J. Exp. Psychol.*, vol. 49, no. 4, 1955, pp. 231-236.
27. Nystrom, Charles O., Morin, Robert E., and Grant, David A. "Effects of Amount, Rate and Stage of Automatically-Paced Training on Self-Paced Performance," *J. Exp. Psychol.*, vol. 49, no. 4, April 1955, pp. 225-230.
28. Nystrom, Charles O., Morin, Robert E., and Grant, David A. "Transfer Effects Between Automatically-Paced Training Schedules in a Perceptual-Motor Task," *J. Gen. Psychol.*, vol. 55, 1956, pp. 9-17.
29. Clark, L. Verdelle. "Effect of Mental Practice on the Development of a Certain Motor Skill," *Res. Quart. Amer. Ass. Hlth. Phys. Educ. Recr.*, vol. 31, no. 4, 1960, pp. 560-569.
30. Adams, Jack A. *Some Considerations in the Design and Use of Dynamic Flight Simulators*, Research Report 57-51, Air Force Personnel and Training Research Center, Lackland AFB, Tex., April 1957.
31. Gagné, Robert M. "Simulators," in *Training Research and Education*, Robert Glaser (ed.), University of Pittsburgh Press, Pittsburgh, 1962, pp. 223-247.
32. Miller, Robert B. *Task and Part-Task Trainers and Training*, Technical Report 60-469, Wright Air Development Division, Wright-Patterson AFB, Ohio, June 1960 (Contractor: American Institute for Research).
33. Lumsdaine, Arthur A. "Design of Training Aids and Devices," in *Human Factors Methods for System Design*, John D. Folley, Jr. (ed.), American Institute for Research, Pittsburgh, 1960.
34. Lumsdaine, Arthur A. "Experimental Research on Instructional Devices and Materials," in *Training Research and Education*, Robert Glaser (ed.), University of Pittsburgh Press, Pittsburgh, 1962, pp. 247-294.
35. Denenberg, Victor H. *The Training Effectiveness of a Tank Hull Trainer*, HumRRO Technical Report 3, February 1954.
36. Cox, John A., Wood, Robert O., Jr., Boren, Lynn M., and Thorne, H. Walter. *Functional and Appearance Fidelity of Training Devices for Fixed-Procedures Tasks*, HumRRO Technical Report 65-4, June 1965.
37. Shriver, Edgar L., Fink, C. Dennis, and Trexler, Robert C. *FORECAST Systems Analysis and Training Methods for Electronics Maintenance Training*, HumRRO Research Report 13, May 1964.

Additional References

- Fitts, Paul M. "Factors in Complex Skill Training," in *Training Research and Education*, Robert Glaser (ed.), University of Pittsburgh Press, Pittsburgh, 1962, pp. 177-198.
- Fitts, Paul M. "Perceptual-Motor Skill Learning," in *Categories of Human Learning*, Arthur W. Melton (ed.), Academic Press, New York, 1964, pp. 243-285.

Mager, Robert F. *Preparing Objectives for Programmed Instruction*, Fearon Publishers, San Francisco, 1961.

Chapter 3

The Practice of Knowledge

38. Arnoult, Malcolm D. "Transfer of Predifferentiation Training in Simple and Multiple Shape Discrimination," *J. Exp. Psychol.*, vol. 45, no. 6, June 1953, pp. 401-409.
39. Arnoult, Malcolm D. "Stimulus Predifferentiation: Some Generalizations and Hypotheses," *Psychol. Bull.*, vol. 54, no. 4, July 1957, pp. 339-350.
40. Bailey, Joan H., and Jeffrey, Wendell E. "Response Strength and Association Value in Stimulus Predifferentiation," *Psychol. Rep.*, vol. 4, no. 4, December 1958, pp. 715-721.
41. Baker, Katherine E., and Wylie, Ruth C. "Transfer of Verbal Training to a Motor Task," *J. Exp. Psychol.*, vol. 40, no. 5, October 1950, pp. 632-638.
42. deRivera, Joseph H. "Some Conditions Governing the Use of the Cue Producing Response as an Explanatory Device," Report No. 2, U.S. Naval School of Aviation Medicine, U.S. Naval Aviation Medical Center, Pensacola, Fla., January 1958.
43. Eckstrand, Gordon A., and Morgan, Ross L. *The Influence of Training on the Tactual Discriminability of Knob Shapes*, Technical Report 56-8, Aero Medical Laboratory, Wright Air Development Center, Wright-Patterson AFB, Ohio, January 1956.
44. Gagné, R.M., and Baker, K.E. "Stimulus Pre-differentiation as a Factor in Transfer of Training," *J. Exp. Psychol.*, vol. 40, no. 4, August 1950, pp. 439-451.
45. Gagné, Robert M., Baker, Katherine E., and Foster, Harriet. "Transfer of Discrimination Training to a Motor Task," *J. Exp. Psychol.*, vol. 40, no. 3, June 1950, pp. 314-328.
46. Hake, Harold W., and Eriksen, Charles W. "Role of Response Variables in Recognition and Identification of Complex Visual Forms," *J. Exp. Psychol.*, vol. 52, no. 4, 1956, pp. 235-243.
47. Kinkade, R.G., and Kidd, J.S. *The Use of an Operational Game as a Method of Task Familiarization*, Technical Report 59-204, Aero Medical Laboratory, Wright Air Development Center, Wright-Patterson AFB, Ohio, July 1959 (Contractor: Ohio State University).
48. McAllister, Dorothy Elsey. "The Effects of Various Kinds of Relevant Verbal Pretraining on Subsequent Motor Performance," *J. Exp. Psychol.*, vol. 46, no. 5, 1953, pp. 329-336.
49. Rossman, Irma L., and Goss, Albert E. "The Acquired Distinctiveness of Cues: The Role of Discriminative Verbal Responses in Facilitating the Acquisition of Discriminative Motor Responses," *J. Exp. Psychol.*, vol. 42, no. 3, September 1951, pp. 173-182.
50. Holton, Ruth B., and Goss, Albert E. "Transfer to a Discriminative Motor Task as a Function of Amount and Type of Preliminary Verbalization," *J. Gen. Psychol.*, vol. 55, First Half, July 1956, pp. 117-126.
51. Goss, Albert E., and Greenfeld, Norman. "Transfer to a Motor Task as Influenced by Conditions and Degree of Prior Discrimination Training," *J. Exp. Psychol.*, vol. 55, no. 3, March 1958, pp. 258-269.
- (i) Smith, Robert G., Jr. *The Development of Training Objectives*, HumRRO Research Bulletin 11, June 1964.
52. Gilbert, Thomas F. "Mathetics: The Technology of Education," *J. Mathetics*, vol. 1, no. 1, January 1962, pp. 7-73.
53. Hoehn, Arthur J. *The Development of Training Programs for First Enlistment Personnel in Electronics Maintenance MOS's: IV. How to Design Training Methods and Materials*, Research Memorandum, HumRRO Division No. 1 (System Operations), Alexandria, Va., February 1960.

- (32) Miller, Robert B. *Task and Part-Task Trainers and Training*, Technical Report 60-469, Wright Air Development Division, Wright-Patterson AFB, Ohio, June 1960 (Contractor: American Institute for Research).
54. Hirsch, Richard S. *The Effects of Knowledge of Test Results on Learning of Meaningful Material*, Human Engineering Report 269-7-30, Special Devices Center, Port Washington, N.Y., September 1952 (Contractor: Pennsylvania State College).
55. Krumboltz, John D., and Bonawitz, Barbara. "The Effect of Receiving the Confirming Response in Context in Programmed Material," *J. Educ. Res.*, vol. 55, no. 9, June-July 1962, pp. 472-475.
56. Bryan, Glenn L., Rigney, Joseph W., and Van Horn, Charles. *An Evaluation of Three Types of Information for Supplementing Knowledge of Results in a Training Technique*, Technical Report No. 19, Electronics Personnel Research, University of Southern California, Los Angeles, April 1957.
57. Dowling, Robert M., and Braun, Harry W. "Retention and Meaningfulness of Material," *J. Exp. Psychol.*, vol. 54, no. 3, 1957, pp. 213-217.
58. Noble, C.E. "The Role of Stimulus Meaning (m) in Serial Verbal Learning," *J. Exp. Psychol.*, vol. 43, no. 6, June 1952, pp. 437-446.
59. Sarason, Irwin G. "The Effect of Associative Value and Differential Motivating Instructions on Serial Learning," *Amer. J. Psychol.*, vol. 70, 1957, pp. 620-623.
60. Hake, Harold W., and Eriksen, Charles W. "Effect of Number of Permissible Response Categories on Learning of a Constant Number of Visual Stimuli," *J. Exp. Psychol.*, vol. 50, no. 3, 1955, pp. 161-167.
61. Helson, Ravenna Mathews, and Cover, Anne. "Specificity-Generality of Classificatory Categories as a Variable in Recall," *Percept. Mot. Skills*, vol. 6, 1956, pp. 233-236.
62. Mathews, Ravenna. "Recall as a Function of Number of Classificatory Categories," *J. Exp. Psychol.*, vol. 47, no. 4, 1954, pp. 241-247.
63. Goldbeck, Robert A., and Campbell, Vincent N. "The Effects of Response Mode and Response Difficulty on Programed Learning," *J. Educ. Psychol.*, vol. 53, no. 3, June 1962, pp. 110-118.
64. Krumboltz, John D., and Weisman, Ronald G. "The Effect of Overt Versus Covert Responding to Programed Instruction on Immediate and Delayed Retention," *J. Educ. Psychol.*, vol. 53, 1962, pp. 89-92.
65. Lambert, Philip, Miller, Donald M., and Wiley, David E. "Experimental Folklore and Experimentation: The Study of Programmed Learning in the Wauwatosa Public Schools," *J. Educ. Res.*, vol. 55, no. 9, June-July 1962, pp. 485-491.
66. Stolurow, L.M., and Walker, C.C. "A Comparison of Overt and Covert Response in Programmed Learning," *J. Educ. Res.*, vol. 55, no. 9, June-July 1962, pp. 421-429.
67. DiVesta, Francis J., and Blake, Kathryn. "The Effects of Instructional Sets on Learning and Transfer," *Amer. J. Psychol.*, vol. 72, 1959, pp. 57-67.
68. Forgas, Ronald H., and Schwartz, Rudolph J. "Efficient Retention and Transfer as Affected by Learning Method," *J. Psychol.*, vol. 43, 1957, pp. 135-139.
69. Kersh, Bert Y. "The Adequacy of 'Meaning' as an Explanation for the Superiority of Learning by Independent Discovery," *J. Educ. Psychol.*, vol. 49, no. 5, 1958, pp. 282-292.
70. Haslerud, G.M., and Meyers, Shirley. "The Transfer Value of Given and Individually Derived Principles," *J. Educ. Psychol.*, vol. 49, no. 6, December 1958, pp. 293-298.
71. Underwood, Benton J. "Ten Years of Massed Practice on Distributed Practice," *Psychol. Rev.*, vol. 68, no. 4, July 1961, pp. 229-247.

72. Arnoult, Malcolm D. *A Comparison of Training Methods in the Recognition of Spatial Patterns*, Research Report 56-27, Skill Components Research Laboratory, Air Force Personnel and Training Research Center, Lackland AFB, Tex., February 1956.
73. Eisner, Sigmund, and Rohde, Kermit. "Note Taking During or After the Lecture," *J. Educ. Psychol.*, vol. 50, no. 6, December 1959, pp. 301-304.
74. McClendon, Paul I. "An Experimental Study of the Relationship Between the Note-Taking Practices and Listening Comprehension of College Freshmen During Expository Lectures," *Speech Monogr.*, vol. 25, 1958, pp. 222-228.
75. Green, Edward J. *The Learning Process and Programmed Instruction*, Holt, Rinehart and Winston, Inc., New York, 1962.
76. Lumsdaine, A.A., and Glaser, Robert. (eds.). *Teaching Machines and Programmed Learning: A Source Book*, Department of Audio-Visual Instruction, National Education Association, Washington, 1960.
77. Lysaught, Jérôme P. (ed.). *Programmed Learning: Evolving Principles and Industrial Applications*, Foundation for Research on Human Behavior, Ann Arbor, 1961.
78. Melching, William H., Cox, John A., Rupe, Jesse C., and Smith, Robert G., Jr. *The Text of an Orientation Workshop in Automated Instruction*, Consulting Report, HumRRO Division No. 5 (Air Defense), Fort Bliss, Tex., July 1962.
79. Ofiesh, G.D., and Meierhenry, W.C. (eds.). *Trends in Programmed Instruction*, Department of Audio-Visual Instruction, National Education Association, and National Society for Programmed Instruction, Washington, 1964.
80. Schramm, Wilbur. *The Research on Programed Instruction: An Annotated Bibliography*, Bulletin No. 35 (OE-34034), Office of Education, U.S. Department of Health, Education, and Welfare, Washington, 1964.
81. Stolorow, Lawrence M. *Teaching by Machine*, Cooperative Research Monograph No. 6 (OE-34010), Office of Education, U.S. Department of Health, Education, and Welfare, Washington, 1961.
82. Melching, William H., Smith, Robert G., Jr., Rupe, Jesse C., and Cox, John A. *A Handbook for Programmers of Automated Instruction*, procedural guide, HumRRO Division No. 5 (Air Defense), Fort Bliss, Tex., September 1963.
83. Department of the Army. *Programed Instruction*, Army Pamphlet No. 690-21, Washington, 1964.
84. Pressey, S.L. "Development and Appraisal of Devices Providing Immediate Automatic Scoring of Objective Tests, and Concomitant Self-Instruction," *J. Psychol.*, vol. 29, 1950, pp. 417-447.
85. Schutz, Richard E., and Whittemore, Robert G., Jr. "Procedures for Giving Immediate Reinforcement in Programmed Instruction," *J. Exp. Anal. Behav.*, vol. 5, no. 4, 1962, pp. 541-542.

Additional References

- Finch, G. (ed.). *Educational and Training Media: A Symposium*, National Academy of Sciences, National Research Council, Washington, 1960.
- Gagné, Robert M., and Bolles, Robert C. "A Review of Factors in Learning Efficiency," in *Automatic Teaching: The State of the Art*, E. Galanter (ed.), John Wiley & Sons, Inc., New York, 1959, pp. 13-54.
- (33) Lumsdaine, Arthur A. "Design of Training Aids and Devices," in *Human Factors Methods for System Design*, John D. Folley, Jr. (ed.), American Institute for Research, Pittsburgh, 1960.
 - (34) Lumsdaine, Arthur A. "Experimental Research on Instructional Devices and Materials," in *Training Research and Education*, Robert Glaser (ed.), University of Pittsburgh Press, Pittsburgh, 1962, pp. 247-294.

Chapter 4

The Presentation of Knowledge

86. MacCaslin, Eugene F., Woodruff, Arnold B., and Baker, Robert A. *An Improved Advanced Individual Training Program for Armor*, HumRRO Technical Report 59, December 1959.
87. Carpenter, C.R. *Instructional Film Research Reports (Rapid Mass Learning)*, Human Engineering Report 269-7-36, Special Devices Center, Port Washington, N.Y., January 1953 (Contractor: Pennsylvania State College).
88. U.S. Naval Training Device Center. *Instructional Film Research Reports (Rapid Mass Learning)*, Vol. II, Human Engineering Report 269-7-61, June 1956 (Contractor: Pennsylvania State University).
89. U.S. Naval Training Device Center. *Instructional Television Research Reports*, Human Engineering Report 20-TV-4, June 1956.
90. Aukes, Lewis E., and Simon, George B. *The Relative Effectiveness of an Air Force Training Device Used Intact Versus With Isolated Parts*, Research Report TN-57-77, Maintenance Laboratory, Air Force Personnel and Training Research Center, Lowry AFB, Colo., June 1957.
91. Swanson, Robert A. *The Relative Effectiveness of Training Aids Designed for Use in Mobile Training Detachments*, Technical Report 54-1, Training Aids Research Laboratory, Air Force Personnel and Training Research Center, Chanute AFB, Ill., March 1954.
92. Swanson, Robert A., and Aukes, Lewis E. *Evaluation of Training Devices for B-47 Fuel, Hydraulic and Rudder Power Control Systems*, Research Report TN-56-2, Training Aids Research Laboratory, Air Force Personnel and Training Research Center, Chanute AFB, Ill., January 1956.
93. Torkeison, G.M. *The Comparative Effectiveness of a Mockup, Cutaway, and Projected Charts in Teaching Nomenclature and Function of the 40mm Antiaircraft Weapon and the Mark 13 Type Torpedo*, Technical Report 269-7-100, Special Devices Center, Port Washington, N.Y., March 1954 (Contractor: Pennsylvania State University).
94. Vris, Thomas. *A Comparison of Principles Training and Specific Training Using Several Types of Training Devices*, Technical Report 269-7-102, Special Devices Center, Port Washington, N.Y., July 1955 (Contractor: Pennsylvania State University).
95. Silverman, Robert E. "The Comparative Effectiveness of Animated and Static Transparencies," *J. Appl. Psychol.*, vol. 43, no. 1, February 1959, pp. 16-20.
96. Newman, Slater E., and Highland, Richard W. *The Effectiveness of Four Instructional Methods at Different Stages of a Course*, Research Report 56-68, Training Aids Research Laboratory, Air Force Personnel and Training Research Center, Chanute AFB, Ill., June 1956.
97. Popham, W. James. "Tape Recorded Lectures in the College Classroom," *AV Communications Rev.*, vol. 9, no. 2, March-April 1961, pp. 109-118.
98. Popham, W. James. "Tape Recorded Lectures in the College Classroom-II," *AV Communications Rev.*, vol. 10, no. 2, March-April 1962, pp. 94-101.
99. Follett, J.F. *Effects of Training Response Mode, Test Form, and Measure on Acquisition of Semi-Ordered Factual Materials*, Research Memorandum, HumRRO Division No. 4 (Infantry), Fort Benning, Ga., April 1961.
100. Postman, Leo. "Learned Principles of Organization in Memory," *Psychol. Monogr.*, vol. 68, no. 3 (whole no. 374), 1954, pp. 1-24.
101. Ausubel, David P. "The Use of Advance Organizers in the Learning and Retention of Meaningful Verbal Material," *J. Educ. Psychol.*, vol. 51, no. 5, October 1960, pp. 267-272.

102. Ausubel, David P., and Fitzgerald, Donald. "Organizer, General Background, and Antecedent Learning Variables in Sequential Verbal Learning," *J. Educ. Psychol.*, vol. 53, no. 6, December 1962, pp. 243-249.
103. Klare, George R., Mabry, James E., and Gustafson, Levarl M. "The Relationship of Patterning (Underlining) to Immediate Retention and to Acceptability of Technical Material," *J. Appl. Psychol.*, vol. 39, no. 1, 1955, pp. 40-42.
104. Christenson, C.M., and Stordahl, K.E. "The Effect of Organizational Aids on Comprehension and Retention," *J. Educ. Psychol.*, vol. 46, February 1955, pp. 65-74.
105. Dale, E., and Chall, J.S. "Developing Readable Materials," in *The Fifty-fifth Yearbook of the National Society for the Study of Education, Part II: Adult Reading*, N.B. Henry (ed.), National Society for the Study of Education, Chicago, 1956, pp. 218-250.
106. Klare, George R., Mabry, James E., and Gustafson, Levarl M. *The Relationship of Verbal Communication Variables to Immediate and Delayed Retention and to Acceptability of Technical Training Materials*, Research Bulletin 54-103, Training Aids Research Laboratory, Air Force Personnel and Training Research Center, Chanute AFB, Ill., December 1954 (Contractor: University of Illinois).
107. Rubenstein, Herbert, and Aborn, Murray. "Learning, Prediction, and Readability," *J. Appl. Psychol.*, vol. 42, no. 1, February 1958, pp. 28-32.
108. Department of the Army. *Techniques of Instruction*, Field Manual No. 21-6, Washington, 1954.
109. Beecroft, Robert S., and Anneser, Robert E. "Effectiveness of Increased Repetition in Classroom Learning," paper read at meeting of Midwestern Psychological Association, May 1957.
110. Beecroft, Robert S., and Anneser, Robert E. *Effectiveness of Increased Repetition in Classroom Learning*, Staff Memorandum, HUMRRO Division No. 1 (System Operations), Alexandria, Va., July 1957.

Additional References

- Carpenter, C.R. *Logistics of Sound Motion Pictures for Military Training*, Human Engineering Report 269-7-31, Special Devices Center, Port Washington, N.Y., September 1952 (Contractor: Pennsylvania State College).
- Finch, G. (ed.). *Educational and Training Media: A Symposium*, National Academy of Sciences, National Research Council, Washington, 1960.
- Harcleroad, Fred. "Theoretical Formulations in Audiovisual Communications," *Rev. Educ. Res.*, vol. 32, no. 2, April 1962, pp. 119-126.
- (33) Lumadaine, Arthur A. "Design of Training Aids and Devices," in *Human Factors Methods for System Design*, John D. Folley, Jr. (ed.), American Institute for Research, Pittsburgh, 1960.
 - (34) Lumadaine, Arthur A. "Experimental Research on Instructional Devices and Materials," in *Training Research and Education*, Robert Glaser (ed.), University of Pittsburgh Press, Pittsburgh, 1962, pp. 247-294.

Chapter 5

Management of Students

111. Department of the Army. *Army Personnel Tests and Measurement*, Army Pamphlet No. 611-2, Washington, June 1962.
112. Maslow, A.H. *Motivation and Personality*, Harper & Row, New York, 1954.
113. Katz, Daniel. "Functional Approach to the Study of Attitudes," *Public Opinion Quarterly*, vol. 24, no. 2, Summer 1960, pp. 163-192.

- (79) Ofiesh, G.D., and Meierhenry, W.C. (eds.). *Trends in Programmed Instruction*, Department of Audio-Visual Instruction, National Education Association, and National Society for Programmed Instruction, Washington, 1964.
114. Azrin, N.H. "Use of Rests as Reinforcers," *Psychol. Rep.*, vol. 7, no. 2, October 1960, p. 240.
115. Findlay, Donald C., Matyas, Seymour M., and Rogge, Hermann III. *Training Achievement in Basic Combat Squads With Controlled Aptitude*, HumRRO Technical Report 16, January 1955.
116. Premack, David. "Toward Empirical Behavior Laws: I. Positive Reinforcement," *Psychol. Rev.*, vol. 66, no. 4, July 1959, pp. 219-233.
117. Rudd, W.G.A. "The Psychological Effects of Streaming by Attainment," *Brit. J. Educ. Psychol.*, vol. 28, 1958, pp. 47-60.
118. Cline, Victor B., Beale, Alan, and Seidman, Dennis. *Evaluation of Four-Week and Eight-Week Basic Training for Men of Various Intelligence Levels*, HumRRO Technical Report 32, November 1956.
119. Read, Edwin A., and Crnkovic, John K. *The Continuous Progress Plan*, Brigham Young University, Provo, Utah, 1963.
120. Caro, Paul W., Jr. "The Effect of Class Attendance and Time Structured Content on Achievement in General Psychology," *J. Educ. Psychol.*, vol. 53, April 1962, pp. 76-80.
121. Milton, Ohmer. "Two-Year Follow-up: Objective Data After Learning Without Class Attendance," *Psychol. Rep.*, vol. 11, no. 3, December 1962, pp. 833-836.
122. Aldrich, Nathan S. *An Experiment Within the Concept of Student Self-Teaching*, Research Report No. 4, U.S. Army Adjutant General School, Fort Benjamin Harrison, Ind., February 1964.
123. Brown, George H., Zaynor, Wesley C., Bernstein, Alvin J., and Shoemaker, Harry A. *Development and Evaluation of an Improved Field Radio Repair Course*, HumRRO Technical Report 58, September 1959.
124. Goffard, S. James, Heimstra, Norman W., Beecroft, Robert S., and Openshaw, Joseph W. *Basic Electronics for Minimally Qualified Men: An Experimental Evaluation of a Method of Presentation*, HumRRO Technical Report 61, February 1960.
125. Hitchcock, Lloyd, Jr., Mager, Robert F., and Whipple, James E. *Development and Evaluation of an Experimental Program of Instruction for Fire Control Technicians*, HumRRO Technical Report 46, May 1958.
126. Shoemaker, Harry A. "The Functional Context Method of Instruction," *IRE Transactions on Education*, vol. E-3, no. 2, June 1960, pp. 52-57.
- (1) Smith, Robert G., Jr. *The Development of Training Objectives*, HumRRO Research Bulletin 11, June 1964.
- (86) MacCanlin, Eugene F., Woodruff, Arnold B., and Baker, Robert A. *An Improved Advanced Individual Training Program for Armor*, HumRRO Technical Report 59, December 1959.

Chapter 6

Automation of Instruction

127. Stolurow, Lawrence M. "Implications of Current Research and Future Trends," *J. Educ. Res.*, vol. 55, no. 9, June-July 1962, pp. 519-527.
- (81) Stolurow, Lawrence M. *Teaching by Machine*, Cooperative Research Monograph No. 6 (OE-34010), Office of Education, U.S. Department of Health, Education, and Welfare, Washington, 1961.

128. Coulson, J.E. (ed.). *Programmed Learning and Computer-Based Instruction*, John Wiley & Sons, Inc., New York, 1962, pp. 171-190.
129. Bushnell, Don D. (ed.). *The Automation of School Information Systems*, Monograph No. 1, Department of Audio-Visual Instruction, National Education Association, Washington, 1964.
130. Egbert, R.L., and Cogswell, J.F. *System Design for a Continuous Progress School: Part II Surveillance and Detection System*, Report TM-1493/104/00, System Development Corporation, Santa Monica, 1964.

Additional References

- Bushnell, Don D. "Computer-Based Teaching Machines," *J. Educ. Res.*, vol. 55, no. 9, June-July 1962, pp. 528-531.
- Bushnell, Donald D. "The Role of the Computer in Future Instructional Systems," *AV Communication Rev.*, vol. 11, no. 2, Supplement No. 7, March-April 1963.
- Cogswell, J.F. *The Systems Approach as a Heuristic Method in Educational Development: An Application to the Counseling Function*, Publication SP-720, System Development Corporation, Santa Monica, March 1962.
- Cogswell, J.F., Egbert, R.L., Marsh, D.G., and Yett, F.A. *Construction of School Simulation Vehicle*, Document TM-1409, System Development Corporation, Santa Monica, August 1963.
- Cogswell, John F., Egbert, Robert L., Marsh, Donald G., and Yett, Frank A. *Purpose and Strategy of the School Simulation Project*, TM-1493/100/100, System Development Corporation, Santa Monica, December 1963.
- (83) Department of the Army. *Programed Instruction*, Army Pamphlet No. 690-21, Washington, 1964.
- Egbert, Robert L., and Cogswell, John F. *System Analysis and Design in Schools*, Document SP-1141, System Development Corporation, Santa Monica, March 1963.
- Egbert, R.L., and Cogswell, J.F. *System Design in the Bassett High School*, Document TM-1147, System Development Corporation, Santa Monica, April 1963.
- Finn, James D., Bolvin, Boyd M., and Perrin, Donald G. *A Selective Bibliography on New Media and Instructional Technology*, Staff Paper Number One, Instructional Technology and Media Project, School of Education, University of Southern California, Los Angeles, April 1964.
- (76) Lumsdaine, A.A., and Glaser, R. (eds.). *Teaching Machines and Programmed Learning: A Source Book*, Department of Audio-Visual Instruction, National Education Association, Washington, 1960.
- (78) Melching, William H., Cox, John A., Rupe, Jesse C., and Smith, Robert G., Jr. *The Text of an Orientation Workshop in Automated Instruction*, Consulting Report, HUMRRO Division No. 5 (Air Defense), Fort Bliss, Tex., July 1962.
- (79) Ofiesh, G.D., and Meierhenry, W.C. (eds.). *Trends in Programmed Instruction*, Department of Audio-Visual Instruction, National Education Association, and National Society for Programmed Instruction, Washington, 1964.
- (117) Rudd, W.G.A. "The Psychological Effects of Streaming by Attainment," *Brit. J. Educ. Psychol.*, vol. 28, 1958, pp. 47-60.
- (80) Schramm, Wilbur. *The Research on Programed Instruction: An Annotated Bibliography*, Bulletin No. 35 (OE-34034), Office of Education, U.S. Department of Health, Education, and Welfare, Washington, 1964.
- Stolurow, Lawrence M. "Programed Instruction and Teaching Machines," in *The Impact of the New Media on Education and the Society*, P.H. Rossi and B.J. Biddle (eds.), in preparation.

Stolurow, Lawrence M. *Some Educational Problems and Prospects of a Systems Approach to Instruction*, Technical Report No. 2, Training Research Laboratory, University of Illinois, Urbana, March 1964.

Stolurow, Lawrence M., and Davis, Daniel J. *Teaching Machines and Computer-Based Systems*, Technical Report No. 1, Training Research Laboratory, University of Illinois, Urbana August 1963.

Chapter 7

The General System Plan

- (1) Smith, Robert G., Jr. *The Development of Training Objectives*, HumRRO Research Bulletin 11, June 1964.
- (2) Smith, Robert G., Jr. *Controlling the Quality of Training*, HumRRO Technical Report 65-6, June 1965.

Chapter 8

Design of the Lesson

- (2) Smith, Robert G., Jr. *Controlling the Quality of Training*, HumRRO Technical Report 65-6, June 1965.

Chapter 9

Evaluation of the System

- (2) Smith, Robert G., Jr. *Controlling the Quality of Training*, HumRRO Technical Report 65-6, June 1965.
131. Churchman, C.W., Ackoff, R.L., and Arnoff, E.L. *Introduction to Operations Research*, John Wiley & Sons, Inc., New York, 1957.

Appendix

A CHECK LIST FOR EVALUATING TRAINING

(Correct Answers Are Capitalized)

1. Obtaining information concerning the job for which the student is being trained.
 - a. Is there a procedure for obtaining information about the job? YES no
 - b. Is the procedure applied systematically and consistently? YES no
 - c. Does the procedure collect performance information for meaningful units of activity? YES no
 - d. Is performance information actively sought from sources in the work or life performance situation? YES no
 - e. Is performance information recorded? YES no
 - f. Is performance information used systematically and consistently to identify critical instructional needs? YES no
 - g. Does the procedure provide complete coverage of all likely aspects or occurrences of the desired work or life performance situation? YES no
 - h. Does the procedure identify performance actions, condition, and standards relevant to the work or life situation? YES no
2. Identifying specific training objectives.
 - a. Are decisions about what to teach made on the basis of reliable and valid data? YES no
 - b. Are detailed analyses made of tasks to be taught as a basis for identifying knowledges and skills required for task performance? YES no
 - c. Are all skills and knowledges required for task performance identified? YES no
 - d. Do training objectives state precisely the performance actions, conditions and standards? YES no
 - e. Do specific training objectives use vague terms, such as know, understand, appreciate, familiarize, general knowledge, working knowledge, qualified? yes NO
3. Establishing the sequence of instruction.
 - a. Is there an effective orientation of the student to the entire job to be learned? YES no
 - b. Are there blocks of skills and knowledge taught in isolation from their use in job tasks? yes NO
 - c. Are new skills and knowledges taught only when required in order to master a new task? YES no
 - d. Is the learning of new knowledge followed immediately by practical exercises? YES no
 - e. Is the relation of each new task to be learned to the overall job clearly stated to the student? YES no

4. Designing situations for the practice of performance.		
a. Are practice situations based on an analysis of the task to be learned?	YES	no
b. Does the student practice the entire task?	YES	no
c. Has any part of the task been omitted from practice?	yes	NO
d. Do training devices simulate the task?	YES	no
e. Do instructions for effective use accompany the training device?	YES	no
f. Has the training device been evaluated in terms of developing student proficiency?	YES	no
g. Have training devices vs real equipment been subjected to cost-effectiveness analysis?	YES	no
h. Has the possibility of using obsolete equipment to teach appropriate skills been considered?	YES	no
i. Do trainees receive frequent and immediate knowledge of the effectiveness of their practice?	YES	no
j. Do trainees receive at least one minute rest between practice trials?	YES	no
5. Designing situations for the practice of knowledge.		
a. Is the knowledge to be practiced clearly related to an actual job task?	YES	no
b. Has information representing the job cues provided the student, and the responses he is to make, been identified?	YES	no
c. Has a practice session been planned for?	YES	no
d. Have appropriate practice materials (workbooks, self-instructional programs, flash cards, etc.) been designed?	YES	no
e. Do trainees receive frequent and immediate knowledge of the effectiveness of their practice?	YES	no
f. Do trainees maintain a record of their progress during practice?	YES	no
6. Preparing presentations to the student.		
a. Has the content of the presentation been tested on students to determine, by means of achievement tests, whether it communicates to the students?	YES	no
b. Is the content of the presentation meaningful to the student?	YES	no
c. Are there lengthy periods of presentation uninterrupted by practice?	yes	NO
d. Are films and television integrated with live instruction?	YES	no
e. Are lectures, demonstrations, films, television or tape recordings selected on a cost-effectiveness basis?	YES	no
f. Have texts been examined to be sure that they are within the reading capability of the student?	YES	no
7. Maintaining student learning activity.		
a. Has the degree of spread in aptitude scores of the trainees been determined?	YES	no
b. Have adjustments been made to the training schedule to account for differences in student aptitude?	YES	no
c. Have the interests, educational background, and attitudes toward formal schooling been determined?	YES	no

d. Is this information used to make training presentations more meaningful?	YES	no
e. Do students receive rewards that are significant to them when they achieve course objectives?	YES	no
f. Do student rewards include those that are under the control of the student company commander?	YES	no
g. Has coordination been achieved with the student company commander to make rewards under his control responsive to student performance in the training?	YES	no
h. Are successful students punished?	yes	NO
i. Are failing or borderline students rewarded?	yes	NO
j. Has an analysis been made of the amount and reasons for excused absences from class?	YES	no
k. Have steps been taken to reduce the amount of excused absences to a minimum?	YES	no
8. Control of the quality of the training.		
a. Are the tests direct translations of the training objectives?	YES	no
b. Is emphasis given to performance tests?	YES	no
c. Are grades expressed in percentage passing?	YES	no
d. Are grades based on the bell-shaped normal curve?	yes	NO
e. Are grades based on percentile ranks?	yes	NO
f. Are test items changed to make them easier or harder to conform to an "ideal" distribution of grades?	yes	NO
g. Are results of student testing provided to the instructional departments?	YES	no
h. Do the departments make changes in training procedures suggested by the results of student testing?	YES	no

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13. ABSTRACT This report, based on an extensive survey of current literature, describes and discusses a system approach to designing training and considers factors bearing on training effectiveness. An efficient instructional system is conceived as one in which the components form an integrated whole, achieving maximum effectiveness at the least possible cost. Components considered in this report include presentation media, student management, techniques for practicing knowledge and performance, knowledge of results, directing student activities toward the goals of the training program, and testing and evaluating the system in terms of efficiency and cost. ()		

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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